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THE WIND REGIME IN THE FIRST 62 METERS OF THE ATMOSPHERE

By

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WHITE SANDS MISSILE RANGE, NEW MEXICO

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UNITED STATES ARMY ELECTRONICS COMMAND

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ACKNOWLEDGEMENT

The authors wish to acknowledge the indispensable assistance of Miss Van Dyke Neill whose programming skill made this work possible.

ABSTRACT

Wind regime data in the form of wind roses and frequency of occurrence for nine tower levels by the month and diurnal classification are presented. Results indicate that terrain features in the vicinity of the White Sands Meteorological Research Tower exhibit a modifying effect on the diurnal and seasonal wind regime. It was also found that seasonal variations were in the form of a three season regime system rather than the expected four.

CONTENTS

INTRODUCTION

In 1958 a program was initiated to obtain wind and temperature data for climatological purposes as well as to determine the turbulent characteristics of the lower atmosphere in the vicinity of the Atmospheric Sciences Laboratory's Meteorological Research Tower (Rachele and McClardie, 1957). The data collection program lasted twenty-five months, terminating in April 1960. The climatological aspects of these data were partially analyzed by Carnes (1961) and by Hansen and Neill (1964). The turbulent characteristics of the locale were reviewed by Tourin and Hoidale (1962), Hansen (1963), and Swanson and Cramer (1965). Wind profile prediction techniques were tentatively established using these data by Helvey, Traylor and McClardie (1959), Helvey (1960a, 1960b) and Swanson and Hoidale (1962).

The purpose of this report is to present additional climatological statistics based upon the 25-month data sample. The current presentation is in the form of wind roses for all nine tower levels and percent frequency of occurrence of prevailing wind from the four cardinal and twelve ordinal points of the compass.

DATA ANALYSIS

The 25-month data sample was analyzed utilizing high speed computer techniques with respect to occurrence of prevailing wind direction in five class intervals of wind speed.

The analysis provided monthly summaries of the data for 16 points of the compass for three diurnal classifications (1) daily summary; (2) daylight hours summary; and, (3) nocturnal hours summary. In addition, the percent frequency of occurrence for daylight and nocturnal hours was extracted from the primary computations for each of the sixteen wind directions by month. Wind roses for each tower level by the month and diurnal classification are presented in Figures 1 through 36. Frequency of occurrence for prevailing wind directions is given in Figures 37 to 48.

WIND REGIMES AT WHITE SANDS MISSILE RANGE

A perusal of Figures 1-48 reveals that many wind regimes exist in the first 62 meters of the atmosphere at White Sands Missile Range (WSMR). At first glance the flow characteristics appear to be chaotic and extremely complicated. However, order can be made of chaos, if the terrain features of WSMR are considered. The Missile Range is located in part in the Tularosa Basin of south-central New Mexico. The basin is oriented north-south between the Sacramento and San Andres Ranges of the southern Rockies, is approximately 64 km wide, and slopes gently in a northern direction from 1130m MSL at El Paso, Texas, to 1580m MSL at Carrizozo, New Mexico, at its northern extremity.

The research tower is located about 14 km east of the base of the Organ Mountains of the San Andres Range, the western

boundary of WSMR. The terrain surrounding the tower consists of bare sand, patchy vegetation and brush-covered hillocks one to three meters high. During the data collection period under discussion, the tower was instrumented at nine levels from 4.6 to 62 meters above the surface.

The characteristics of the wind profiles derived from tower data can be considered to be a function of the prevailing synoptic situation, the diurnal temperature regime, and the terrain features of the basin. The orientation and slope of the Tularosa Basin, the proximity of a mountain range upstream along the prevailing wind direction, and an extremely rough surface combine to provide many interrelated wind regimes.

From Figures 1 to 48 it can be noted that there are definite diurnal and seasonal trends in the mean flow in the vicinity of the tower. The months of December and January are dominated by downslope flow along the major axis of the basin. February is a transition month for the daylight hours, but exhibits an abrupt onset of nocturnal drainage winds from the Organ mountains as indicated by the large percentage of westerly winds at night. March and April statistics show the predominant strong westerly flow both day and night. May and June are transition months with the mean flow approaching the prevailing summertime southeasterlies. Drainage from the mountains at night is still significant, especially in June.

July and August are dominated by the southeasterlies, while September is a transition month with some northerly flow

during the day and mountain-valley winds appearing again during the nocturnal hours. October is characterized by light southerly winds, while November is a transition period from the summer-fall seasons to the first phase of the winter season.

A seasonal breakdown of the data reveals that winter has two distinct regimes, that of December-January and February. Spring also has two phases, the extremely windy period of March-April and the transition period May-June. Summer and fall can be combined into the same regime as southeasterly flow generally prevails from mid-June through November.

The extremely high percentage of drainage winds during the noctural hours is a function of the mountainous terrain immediately to the west of the tower location. The Organ Mountains rise abruptly from the basin floor to a height of 2600 m MSL in a horizontal distance of slightly more than 6.5 km. The differential in the rate of cooling of the mountain slopes and the basin floor results in large density differences which in turn lead to the sometimes intense gravity or mountain-valley winds (Berger, 1870).

The gentle slope of the basin proper provides the same mechanism on a smaller scale during the early winter season.

SUMMARY

Wind rose and frequency of occurrence data for a 25-month period have been presented for the first 62 meters of the atmosphere at White Sands Missile Range, New Mexico. The ter-

rain features of the Missile Range are shown to have a significant effect upon the mean flow characteristics such that downslope flow is a predominant characteristic of the nocturnal hours. Seasonal regimes dominate the daytime flow with essentially a three-season year: wincer, sprin, and a combined summer-fall situation.

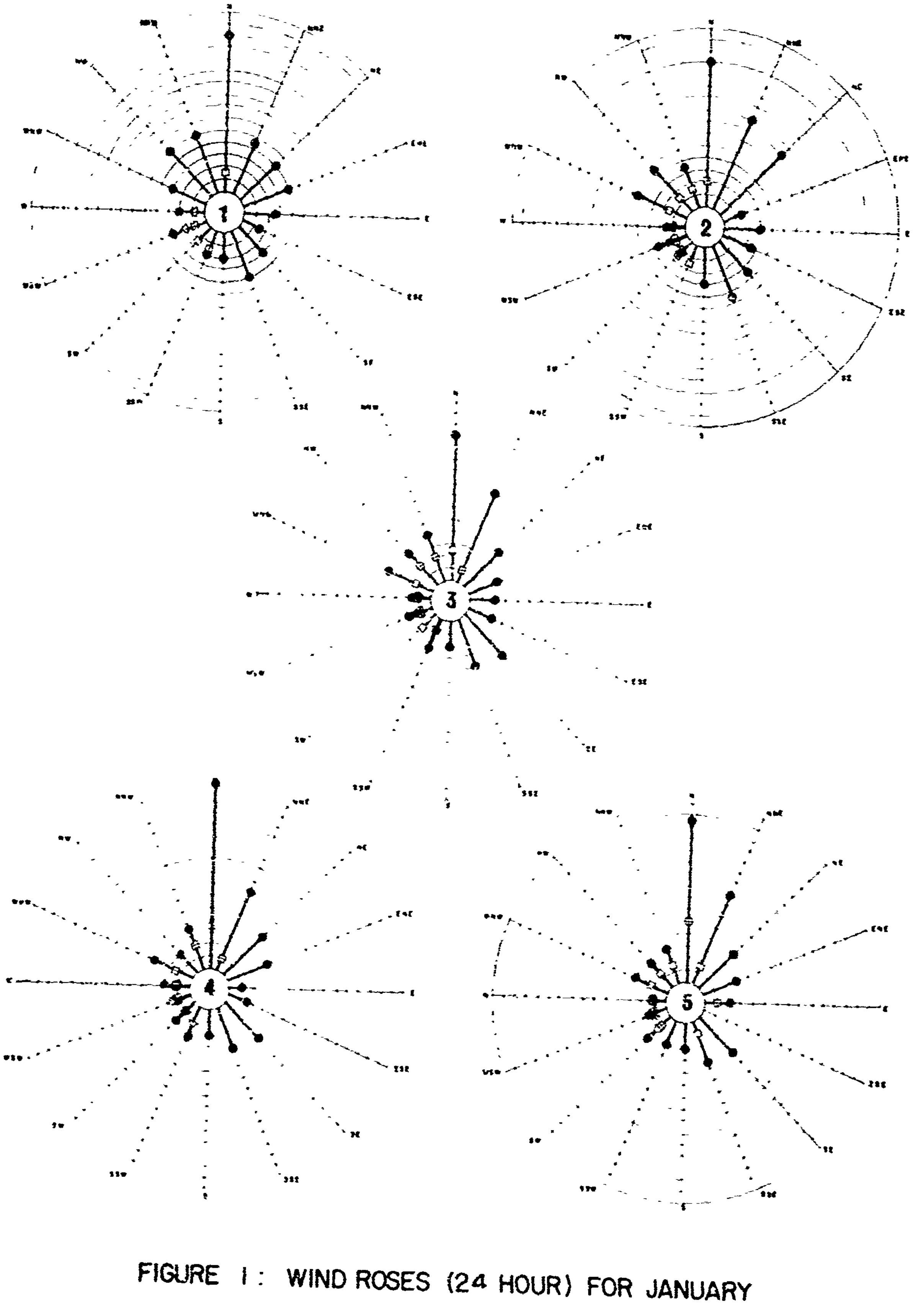


FIGURE 1: WIND ROSES (24 HOUR) FOR JANUARY

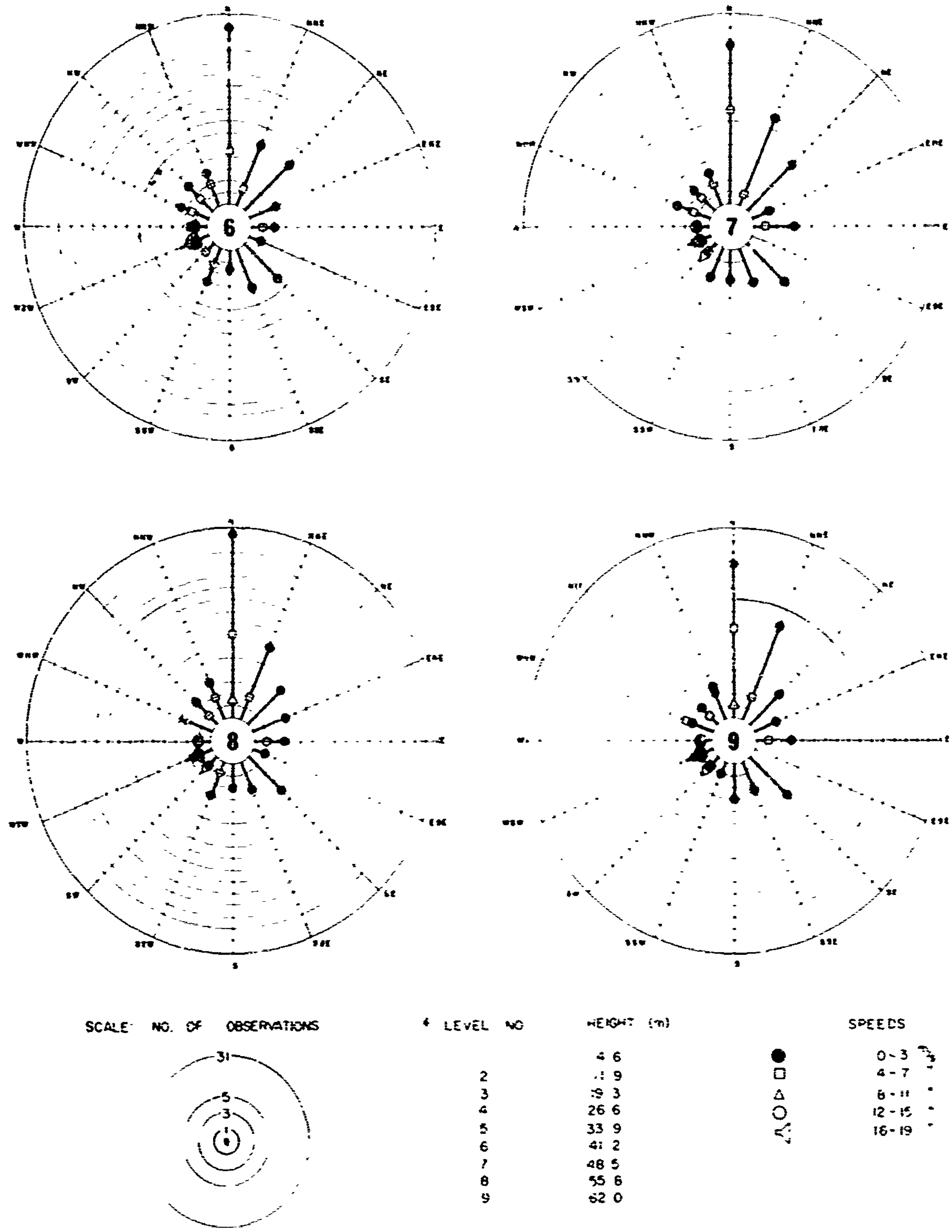


FIGURE I (CONT.): WIND ROSES (24 HOUR) FOR JANUARY

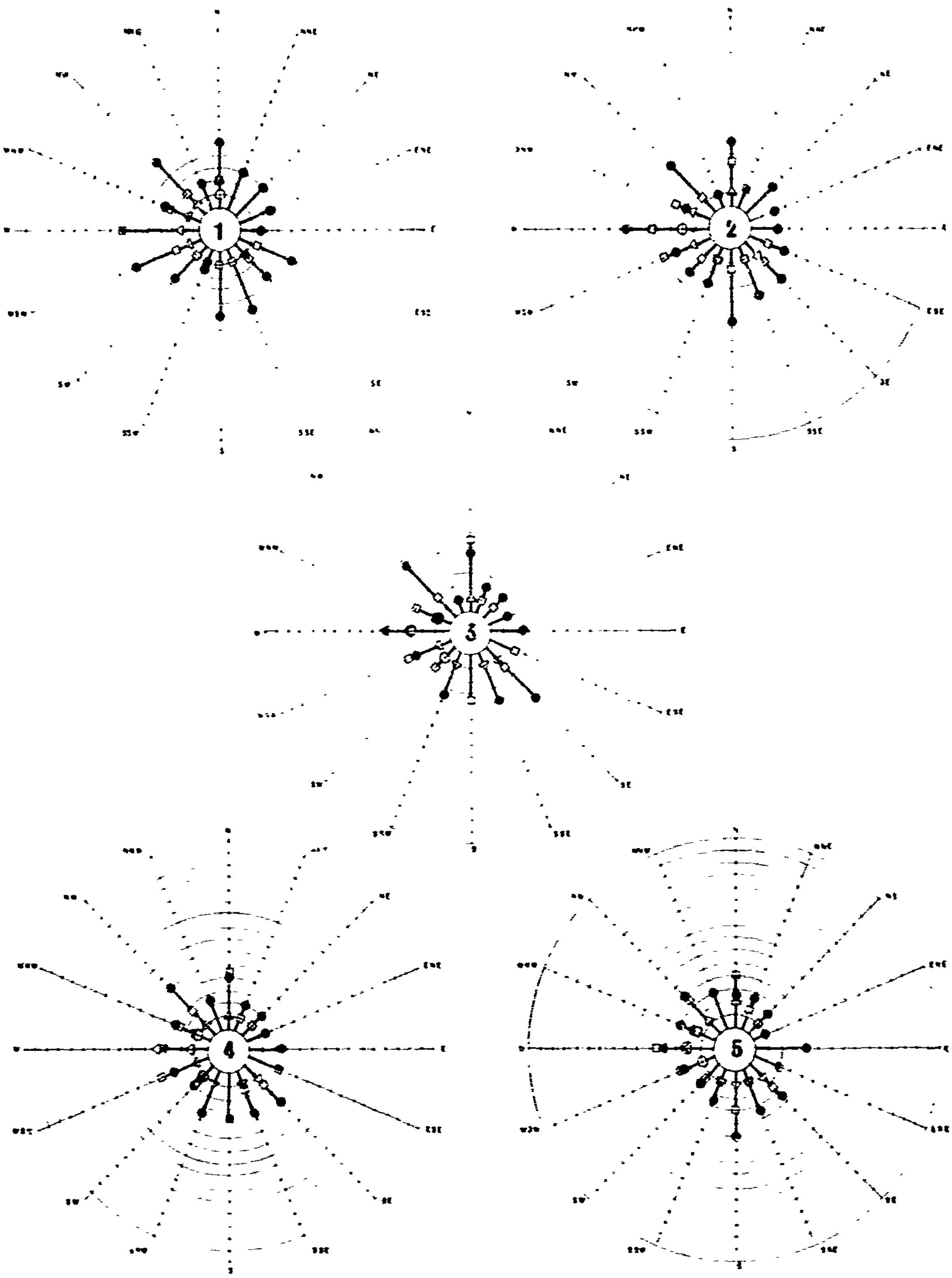


FIGURE 2: WIND ROSES (24 HOUR) FOR FEBRUARY

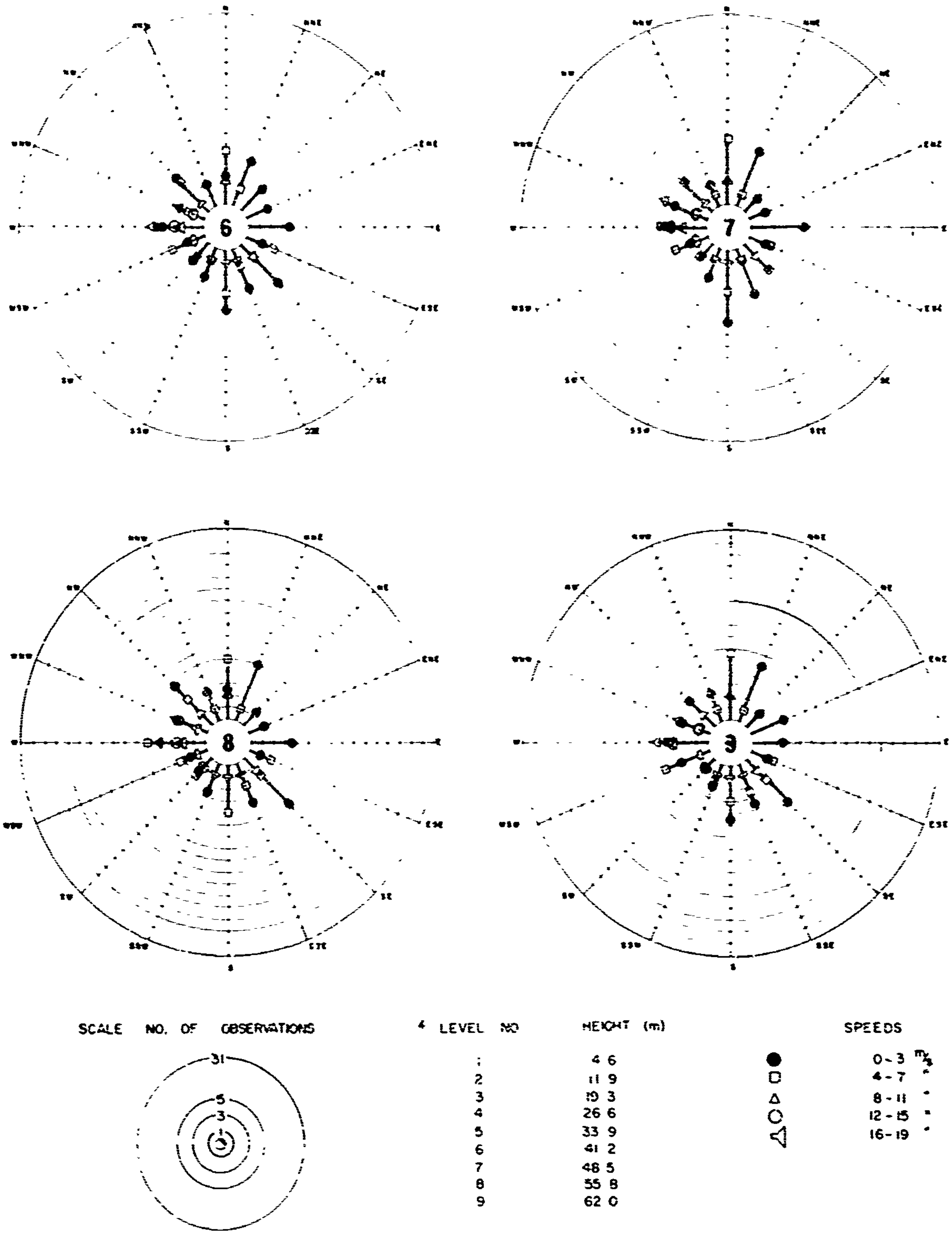


FIGURE 2 (CONT.): WIND ROSES (24 HOUR) FOR FEBRUARY

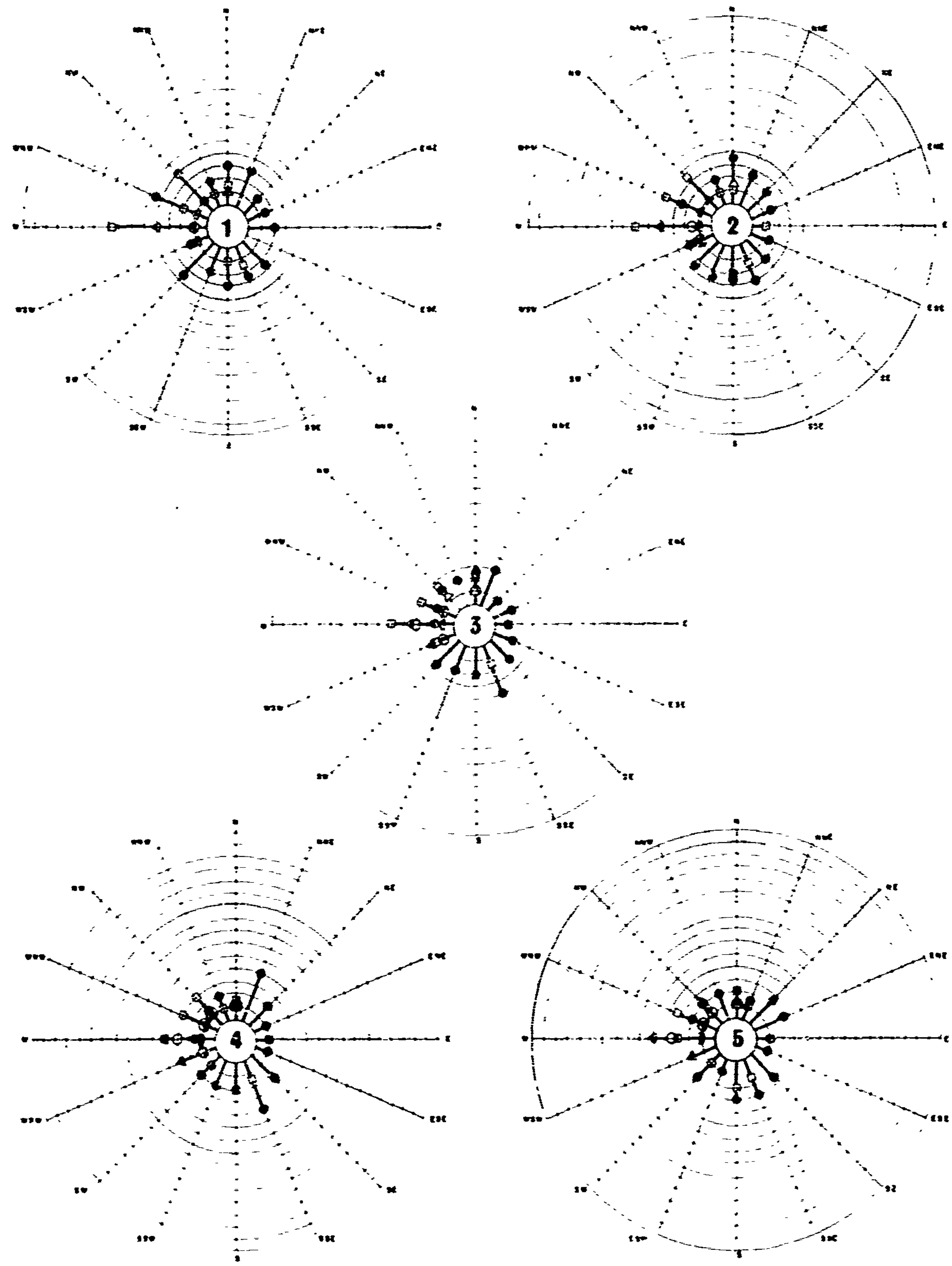


FIGURE 3: WIND ROSES (24 HOUR) FOR MARCH

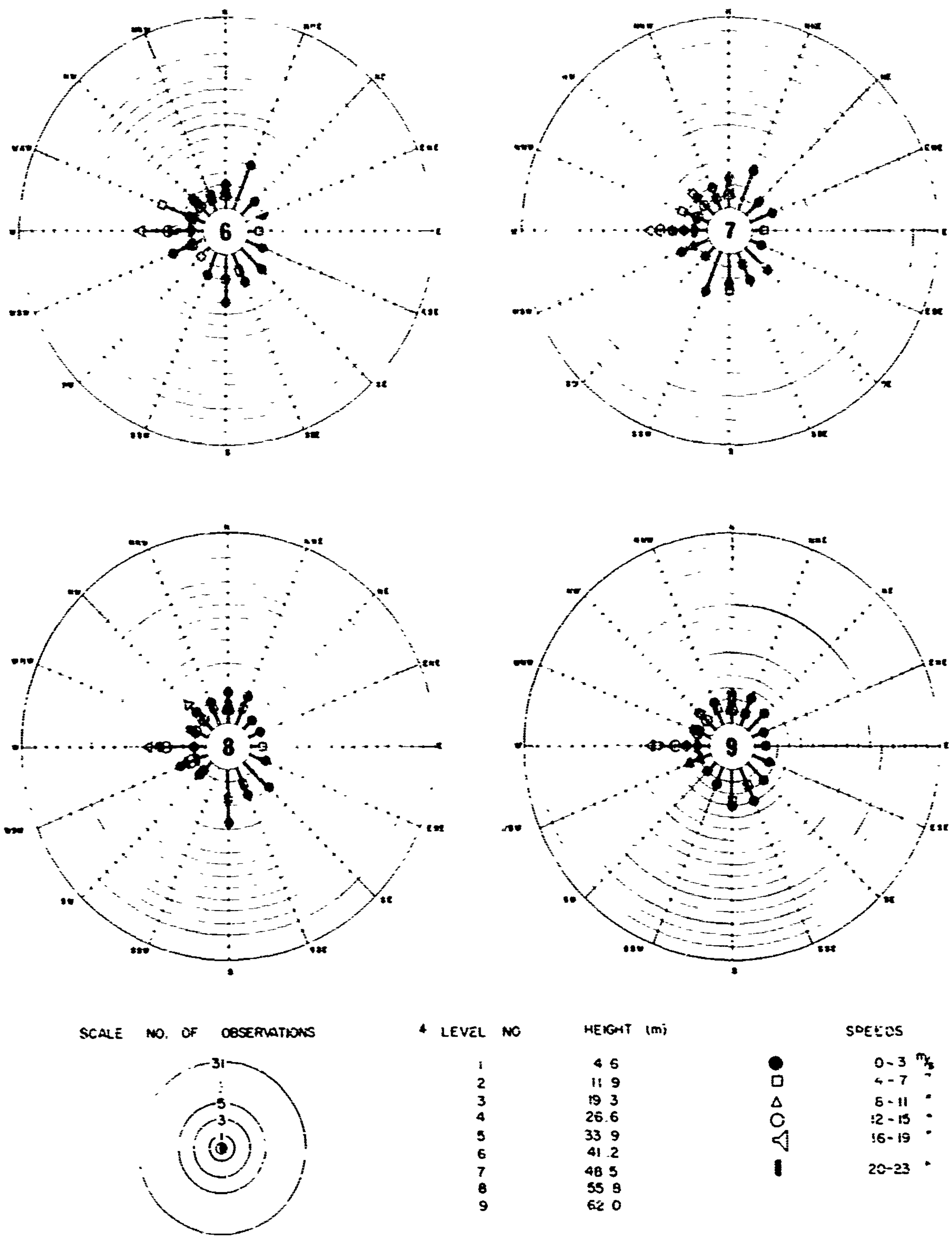


FIGURE 3 (CONT.): WIND ROSES (24 HOUR) FOR MARCH

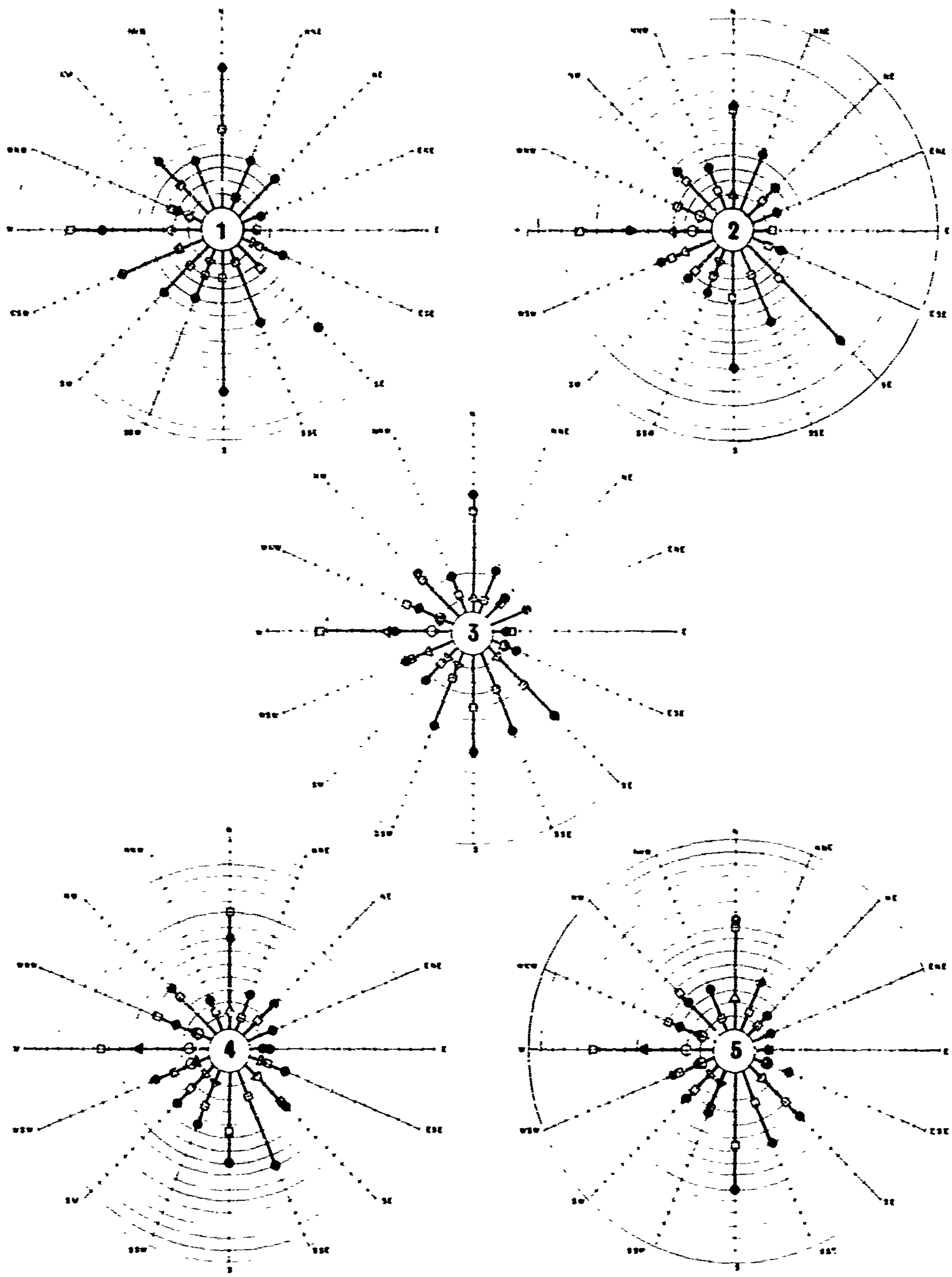
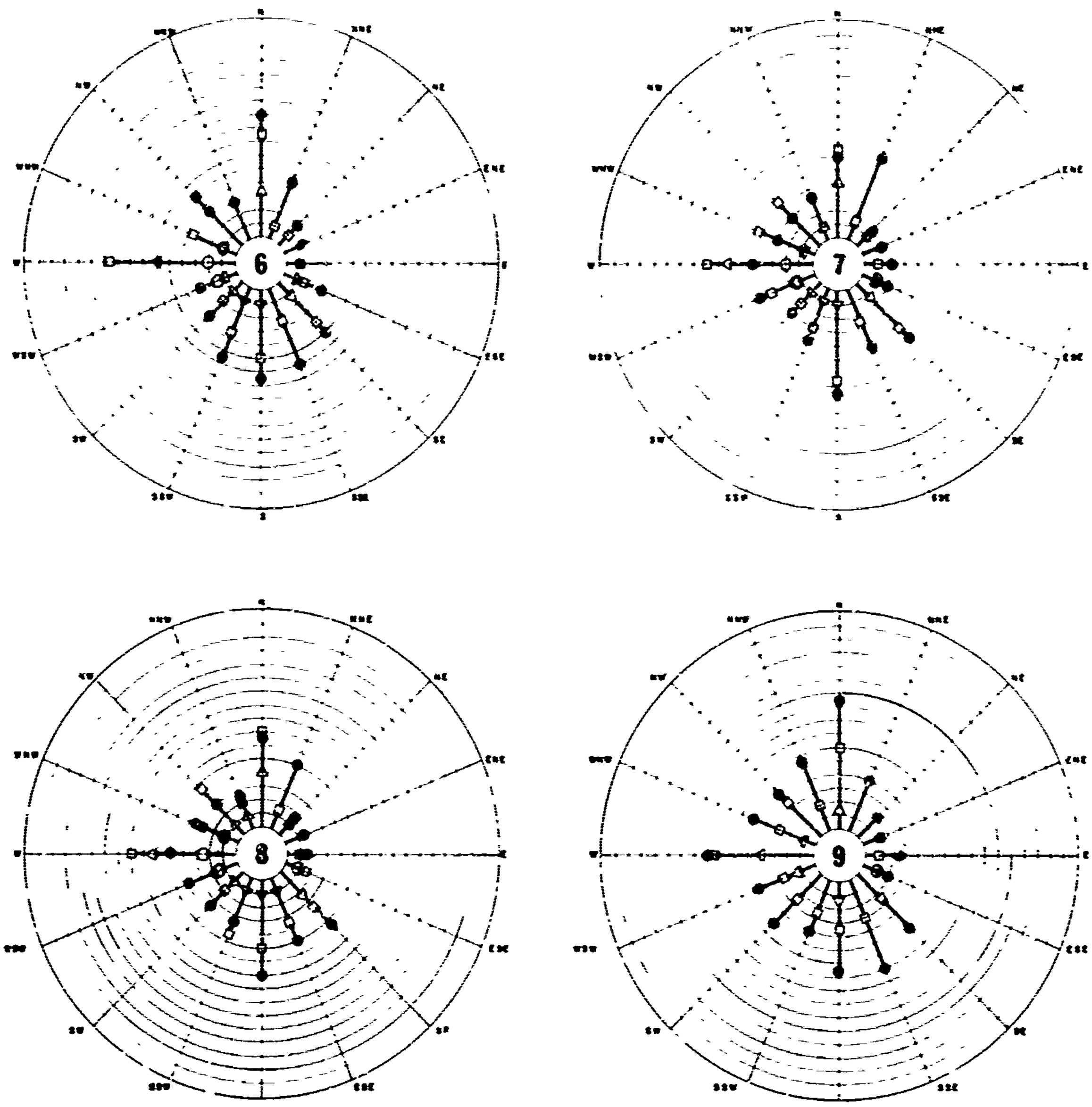


FIGURE 4: WIND ROSES (24 HOUR) FOR APRIL



SCALE: NO. OF OBSERVATIONS	LEVEL NO	HEIGHT (m)	SPEEDS	
	1	4 6	●	0-3 m/s
	2	11 9	□	4-7 "
	3	19 3	△	8-11 "
	4	26 6	○	12-15 "
	5	33 9	◁	16-19 "
	6	41 2		
	7	48 5		
	8	55 8		
	9	62 0		

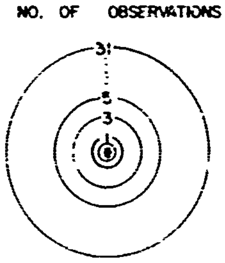


FIGURE 4 (CONT.): WIND ROSES (24 HOUR) FOR APRIL

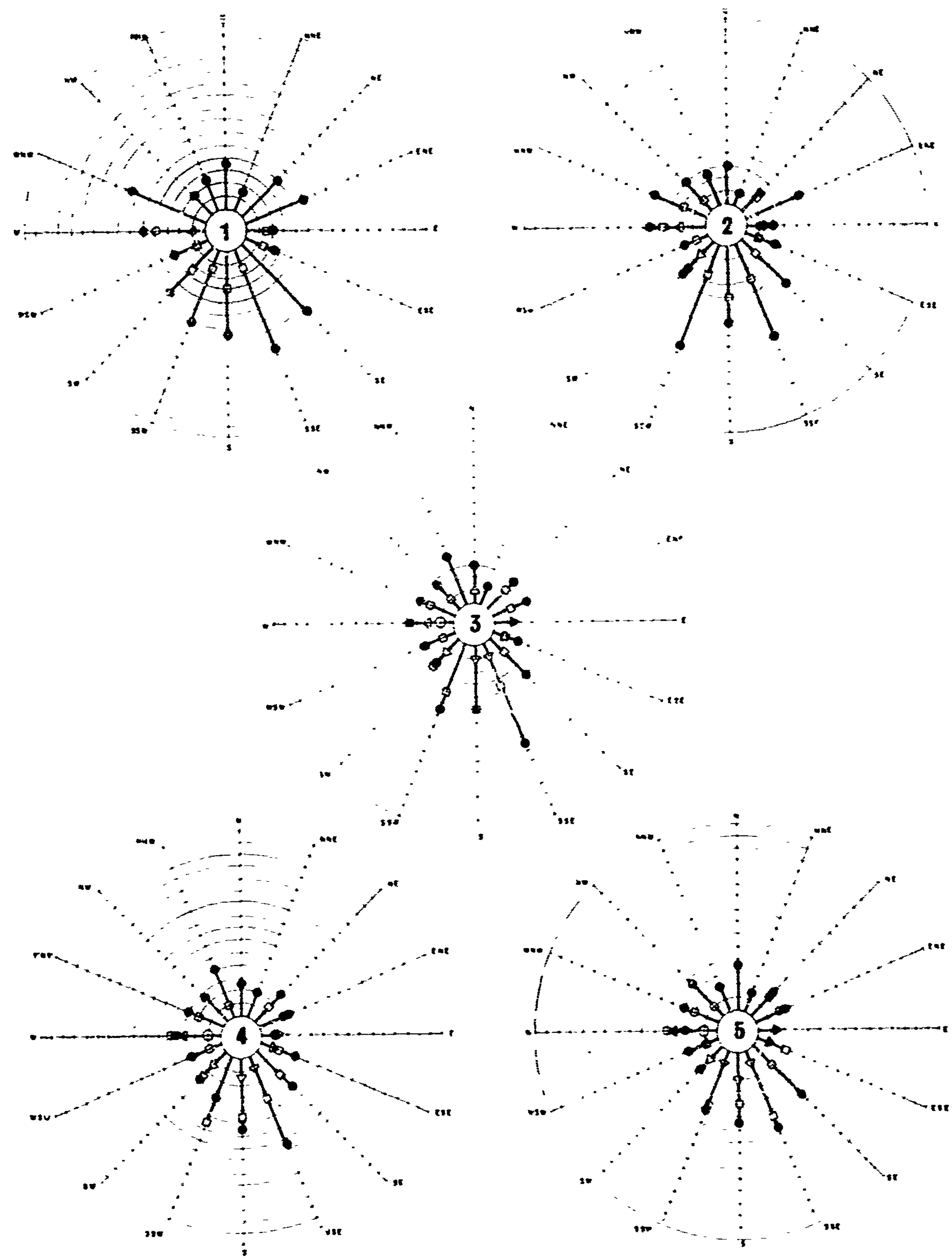
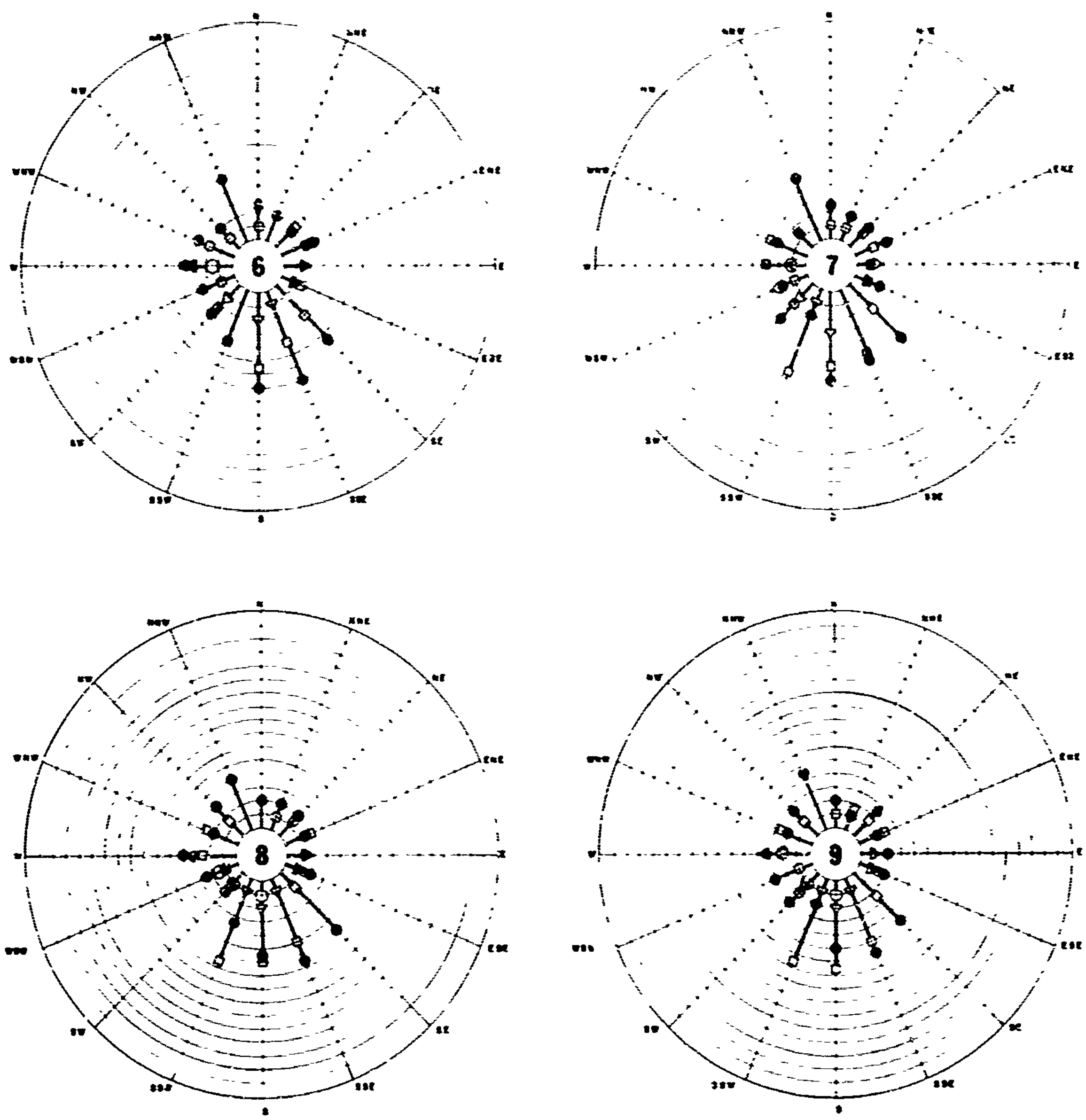
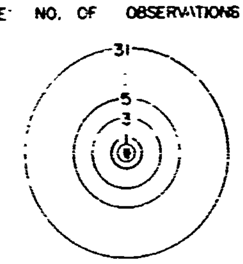


FIGURE 5: WIND ROSES (24 HOUR) FOR MAY



SCALE: NO. OF OBSERVATIONS



LEVEL NO	HEIGHT (m)
1	4 6
2	11 9
3	19 3
4	26 6
5	33 9
6	41 2
7	48 5
8	55 8
9	62 0

SPEEDS

●	0-3 m/s
□	4-7 "
△	8-11 "
○	12-15 "
◁	16-19 "

FIGURE 5 (CONT.): WIND ROSES (24 HOUR) FOR MAY

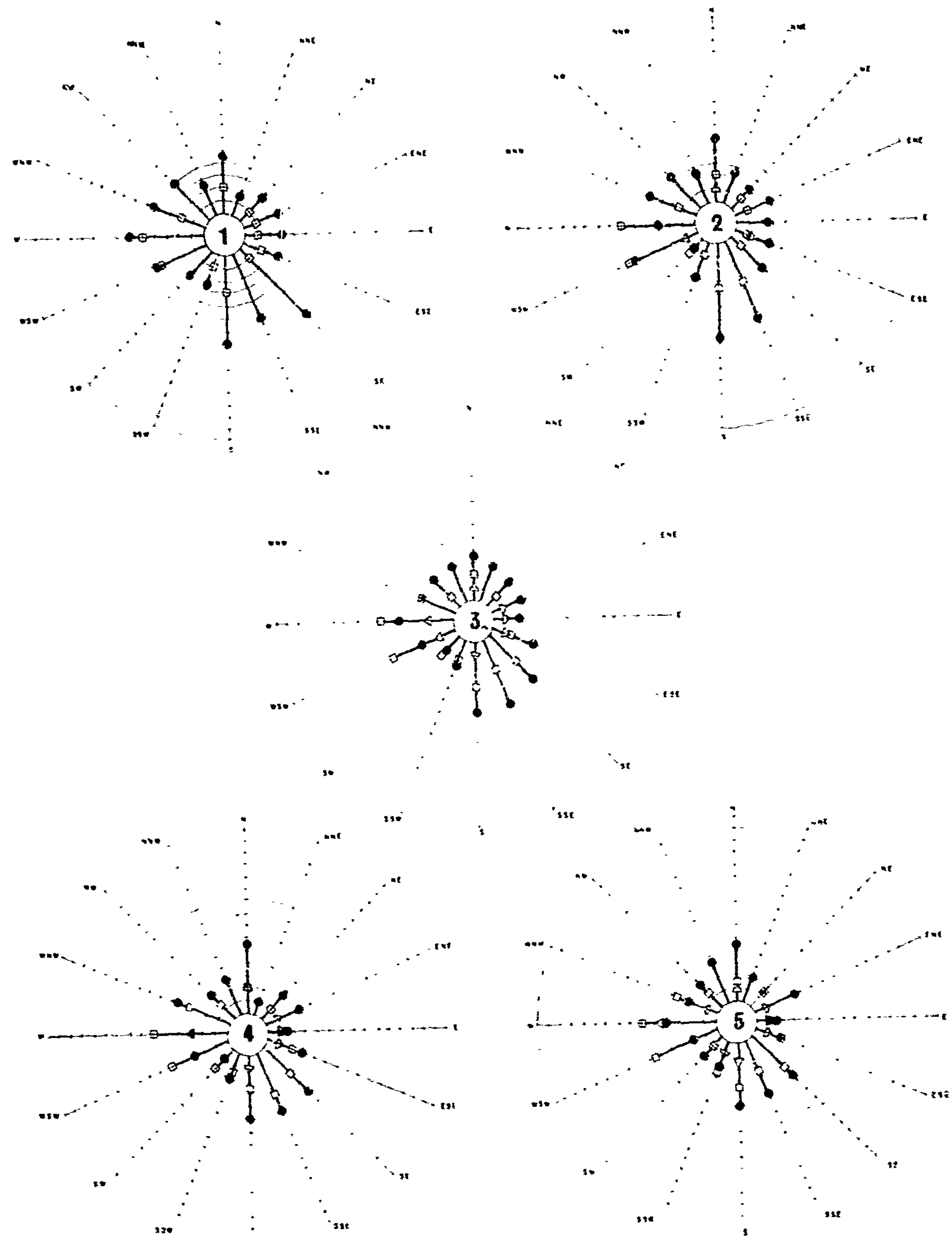


FIGURE 6: WIND ROSES (24 HOUR) FOR JUNE

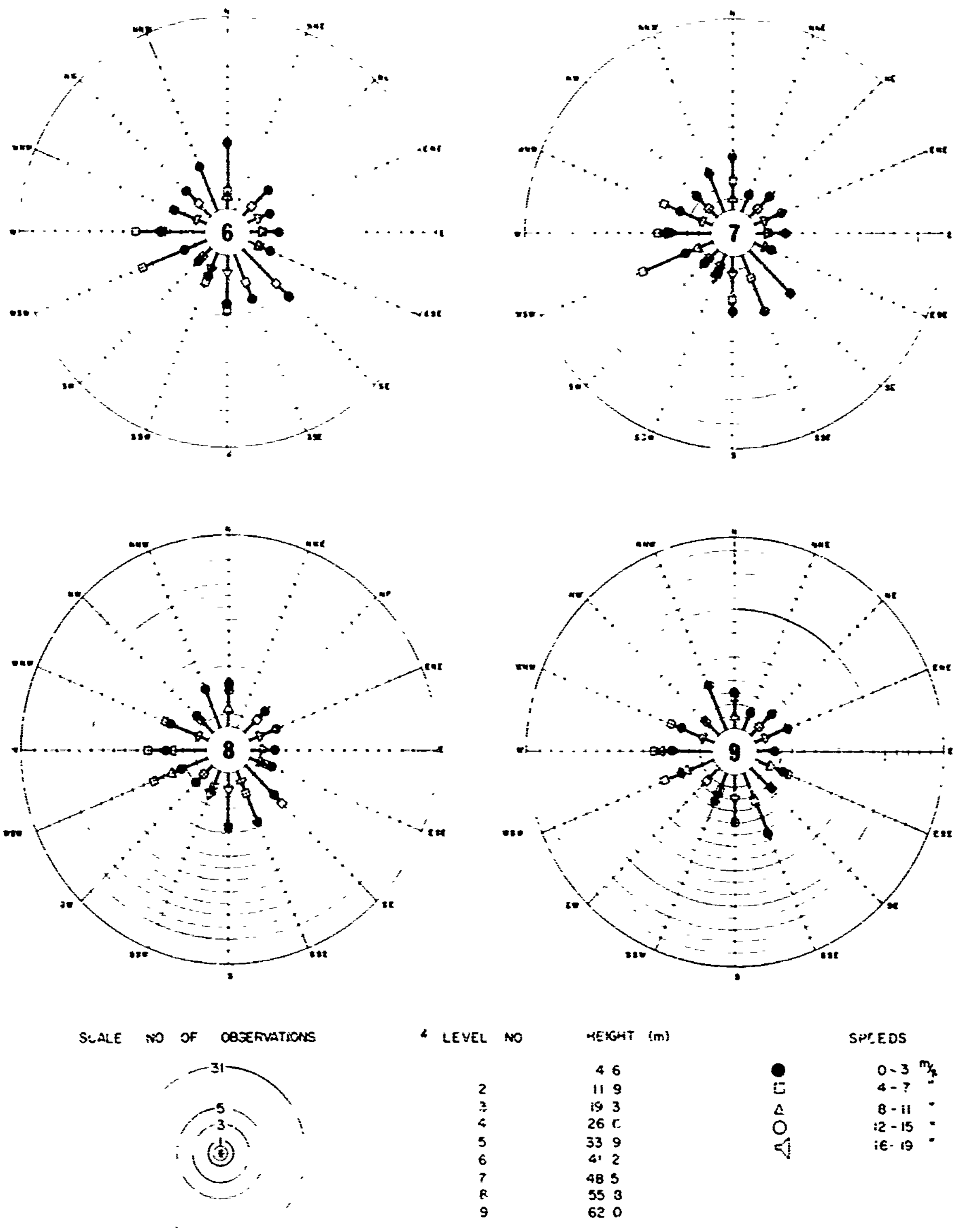


FIGURE 6 (CONT.): WIND ROSES (24 HOUR) FOR JUNE

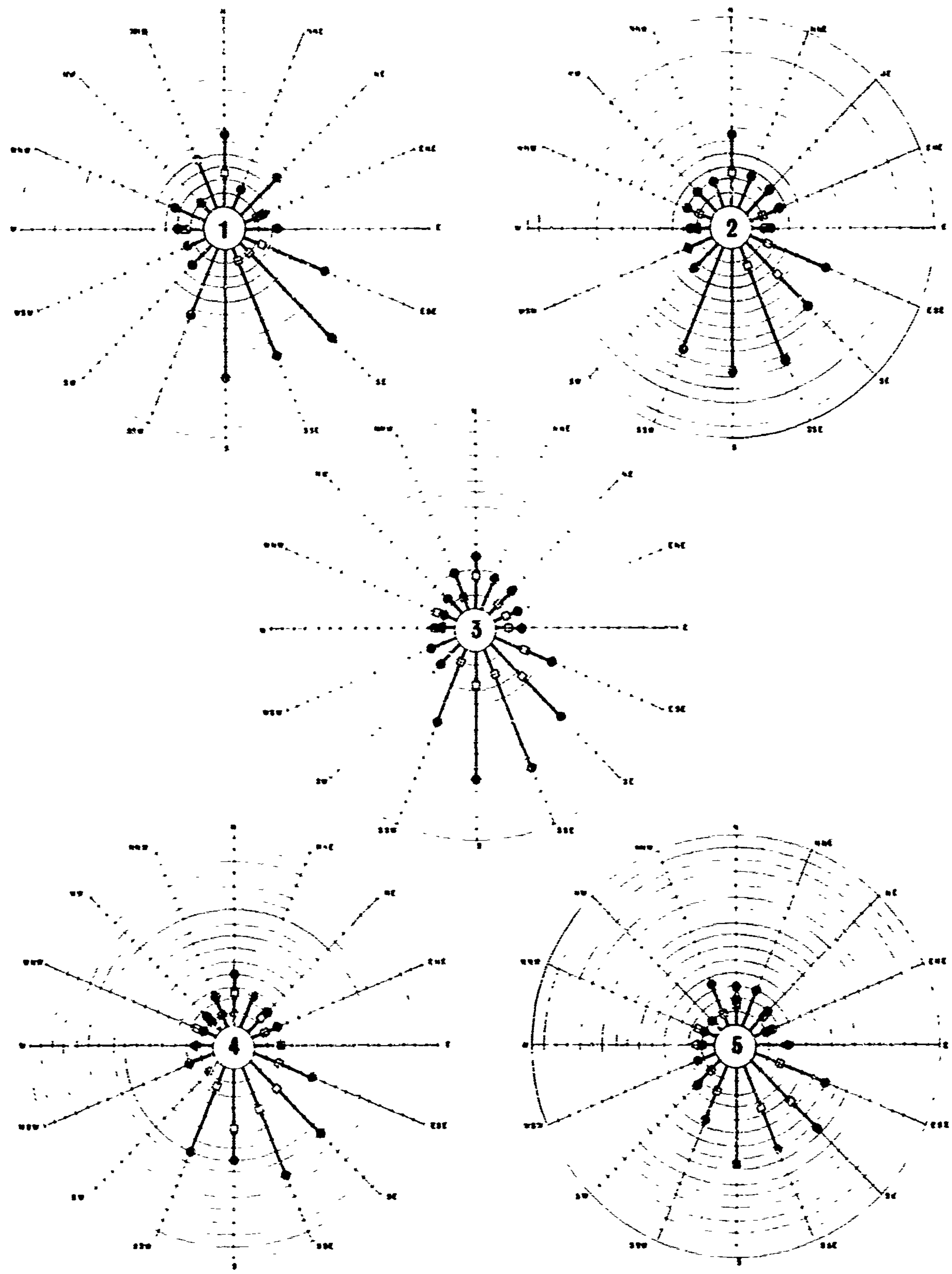


FIGURE 7: WIND ROSES (24 HOUR) FOR JULY

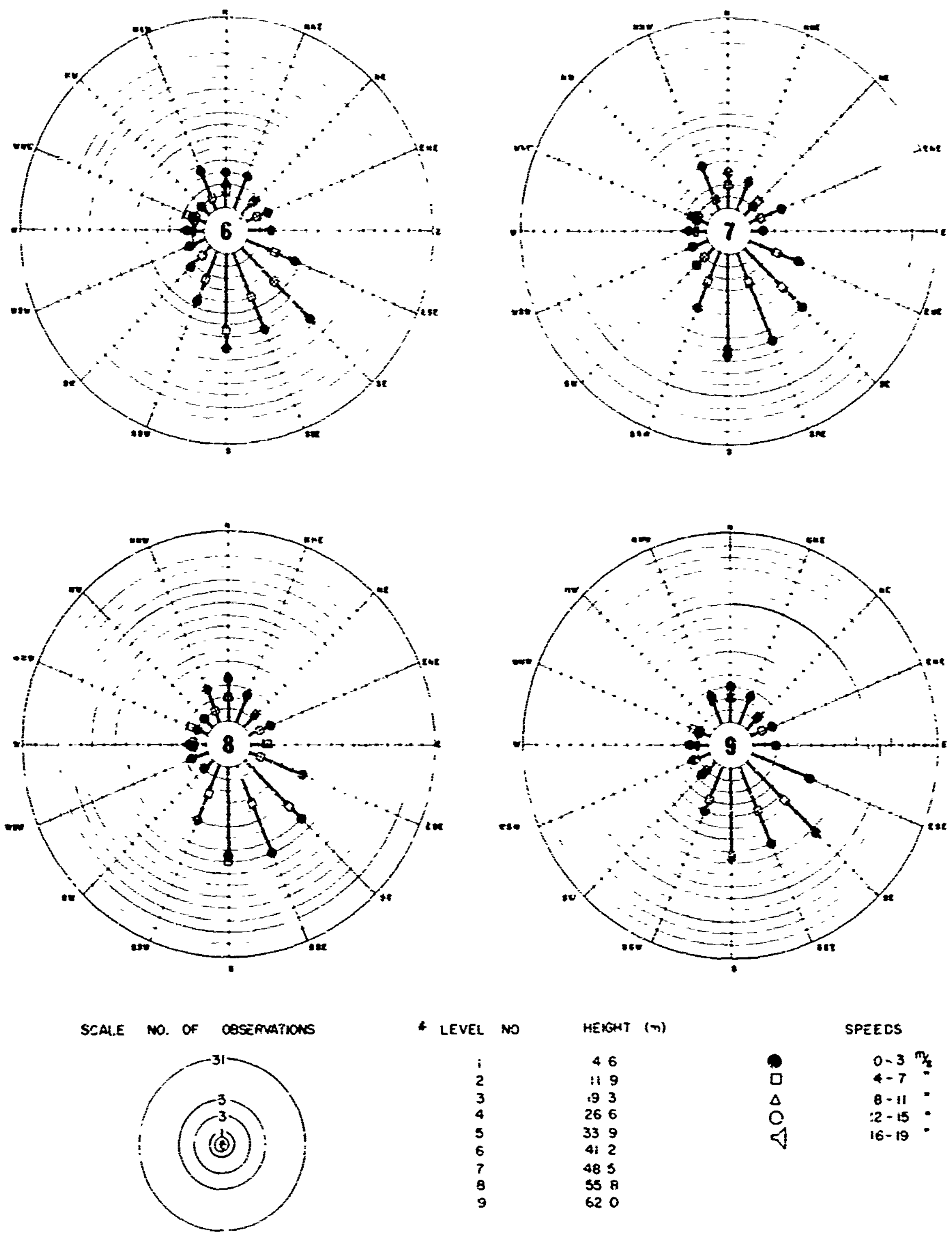


FIGURE 7 (CONT.): WIND ROSES (24 HOUR) FOR JULY

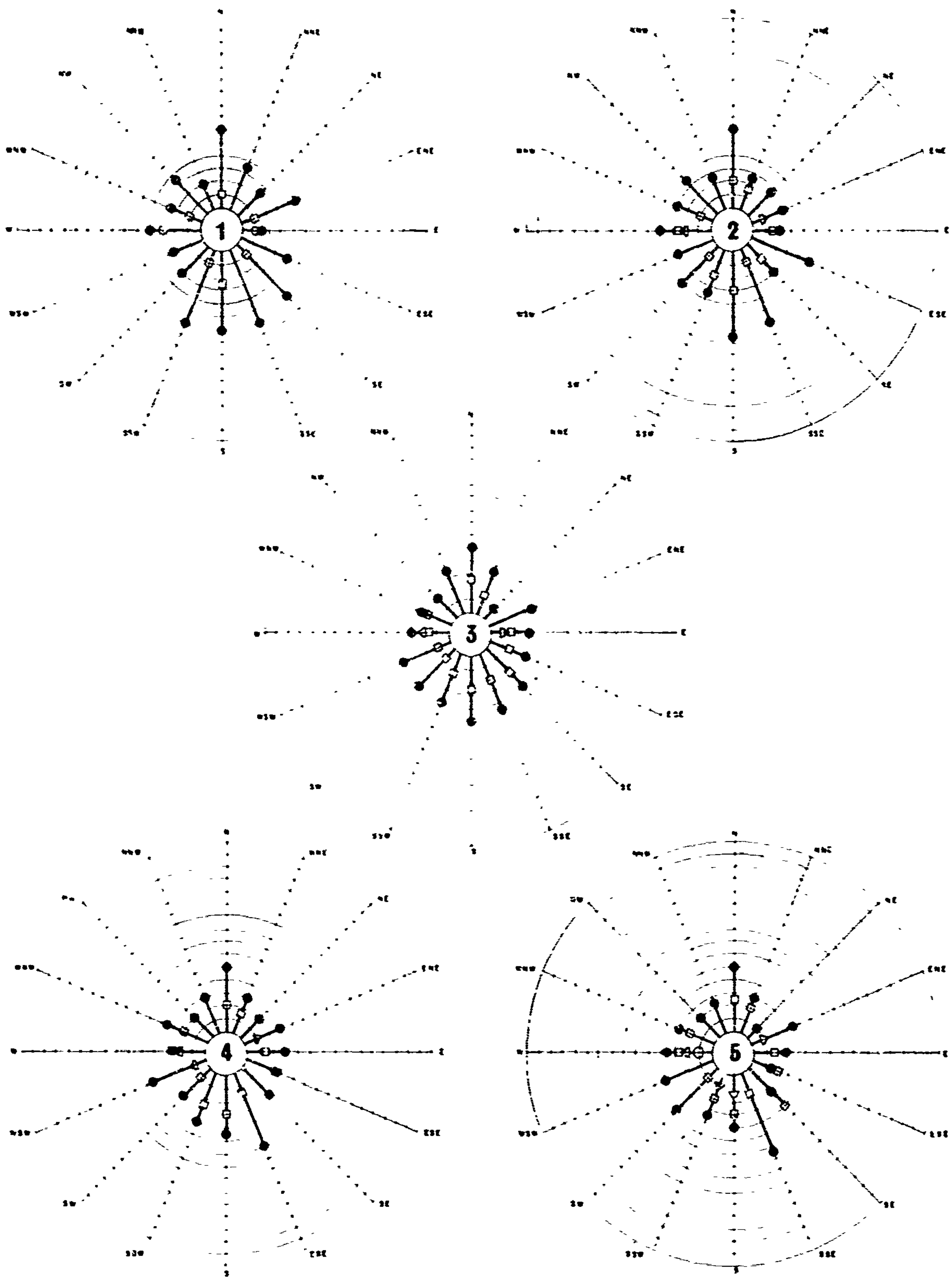


FIGURE 8: WIND ROSES (24 HOUR) FOR AUGUST

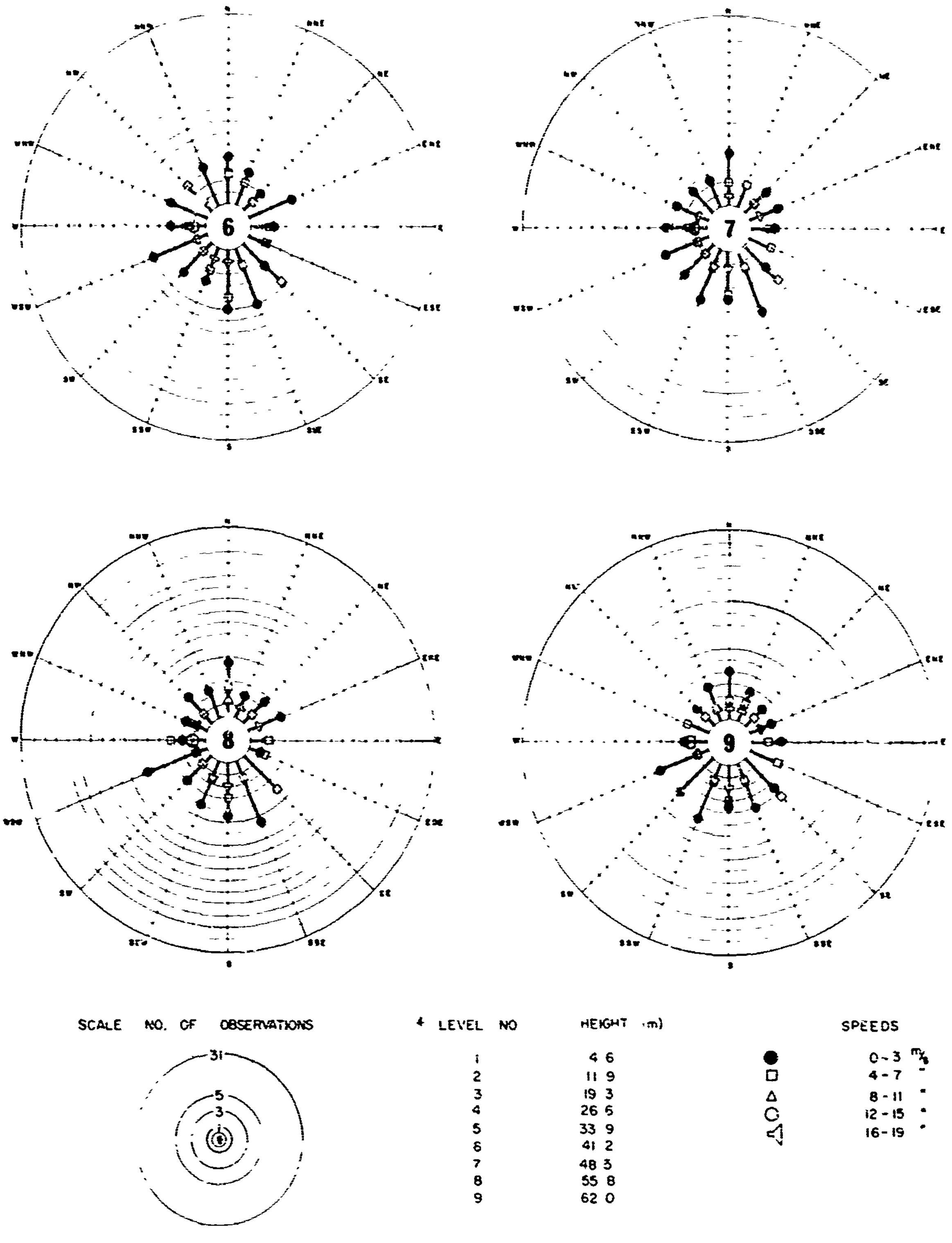


FIGURE 8 (CONT.): WIND ROSES (24 HOUR) FOR AUGUST

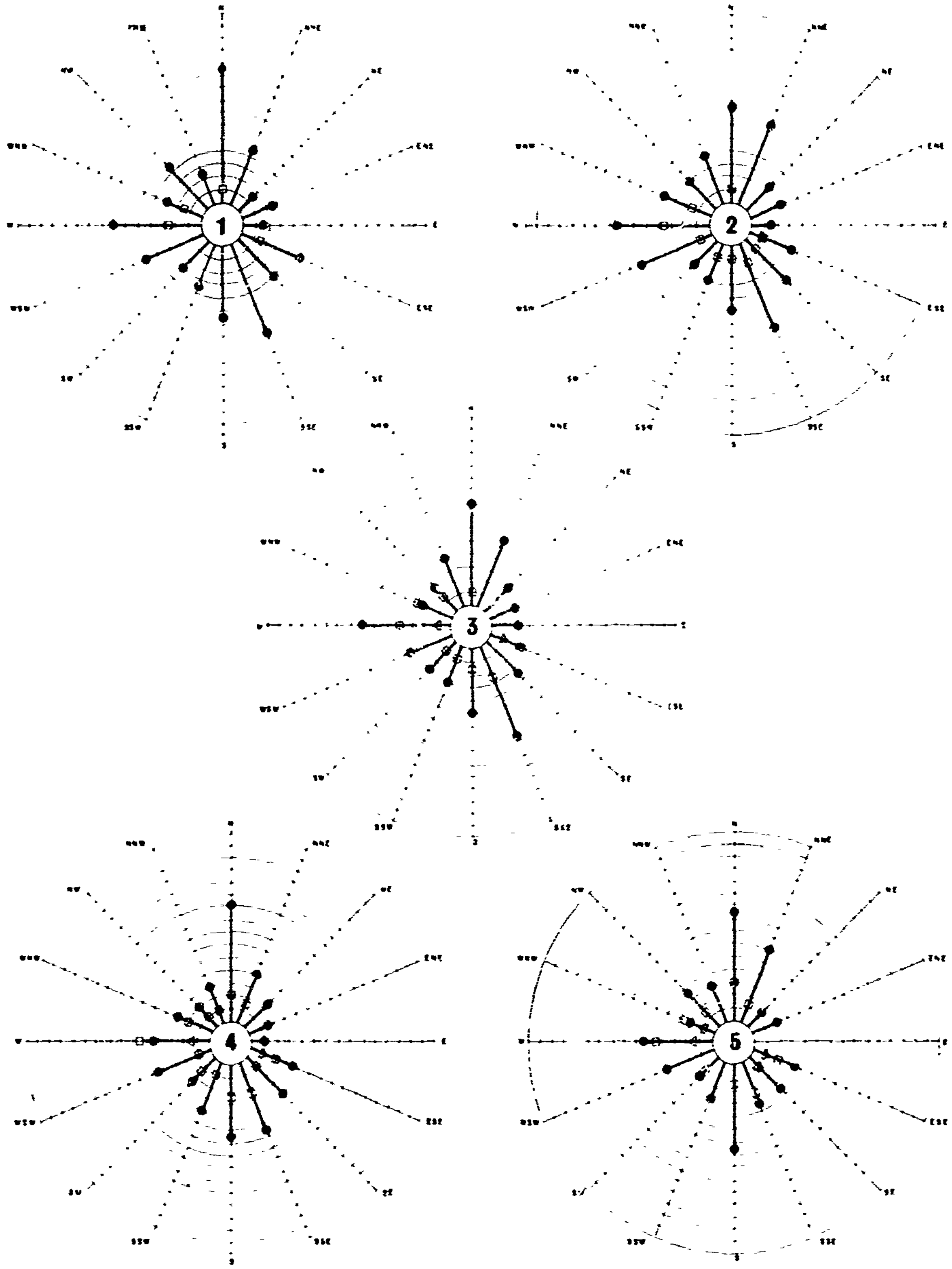
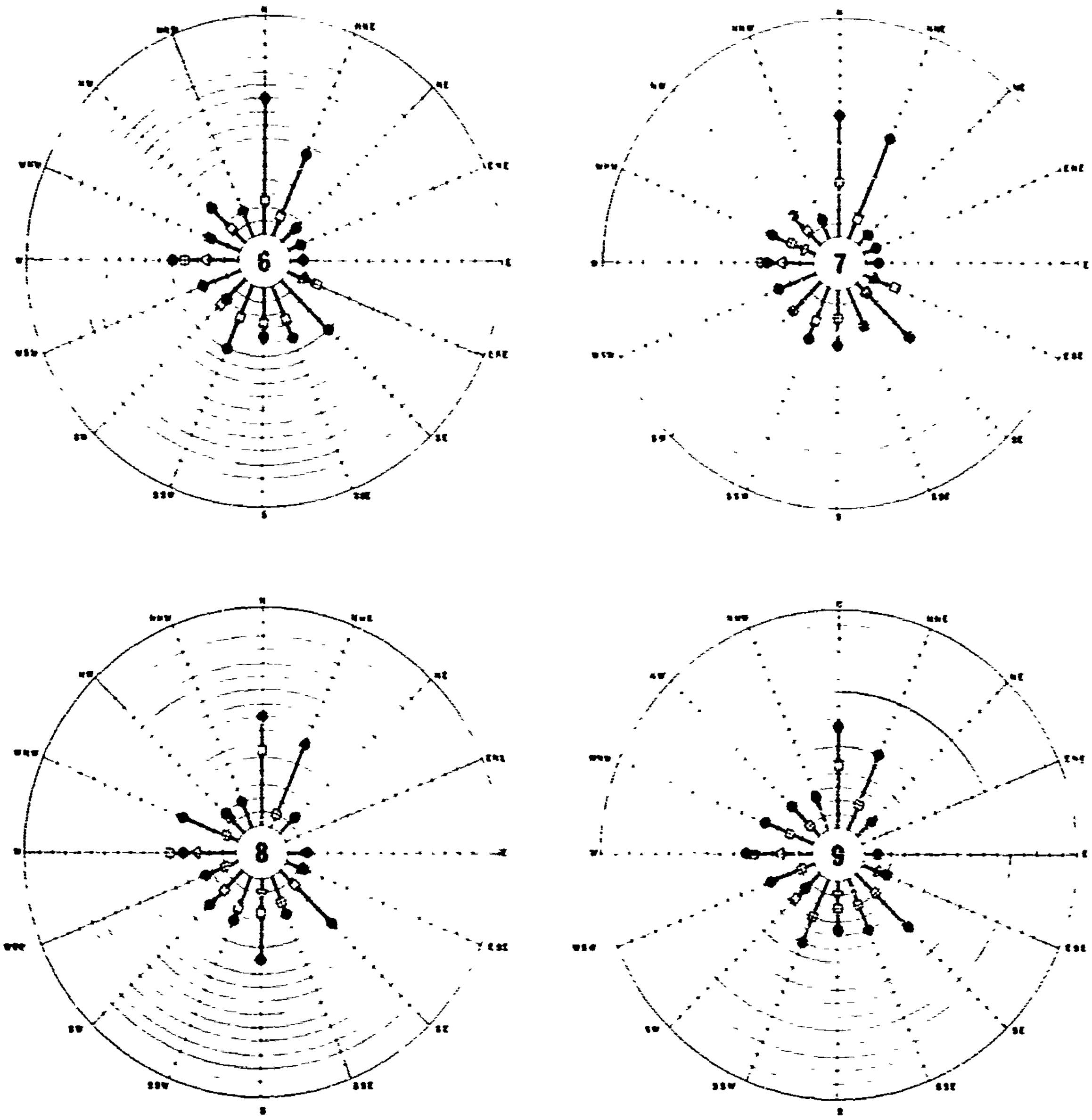
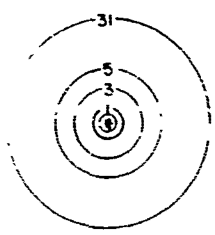


FIGURE 9: WIND ROSES (24 HOUR) FOR SEPTEMBER



SCALE NO. OF OBSERVATIONS



# LEVEL NO	HEIGHT (m)
	4.6
2	11.9
3	19.3
4	26.6
5	33.9
6	41.2
7	48.5
8	55.8
9	62.0

	SPEEDS
●	0-3 m/s
□	4-7 "
△	8-11 "
○	12-15 "
◁	16-19 "

FIGURE 9 (CONT.): WIND ROSES (24 HOUR) FOR SEPTEMBER

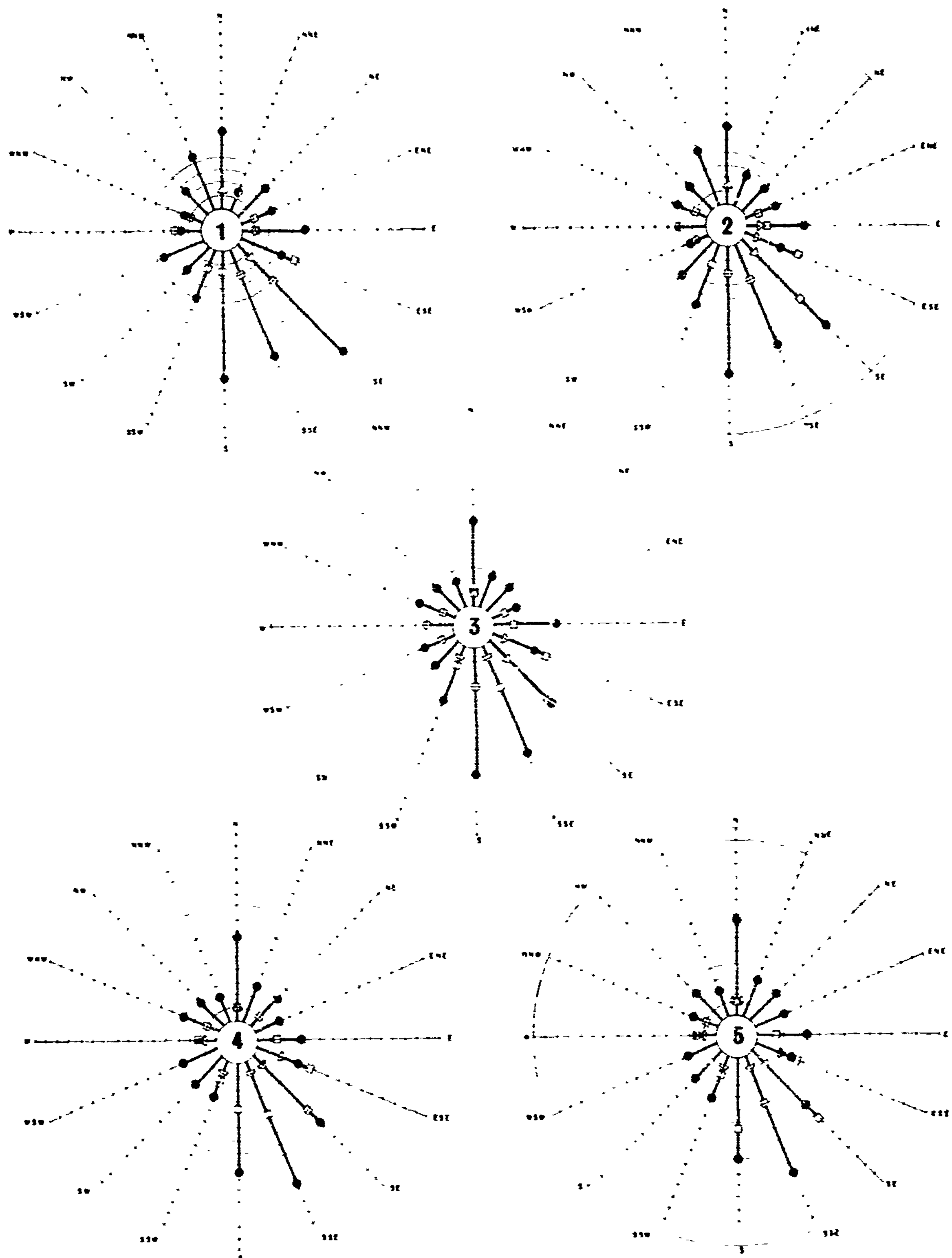


FIGURE 10: WIND ROSES (24 HOUR) FOR OCTOBER

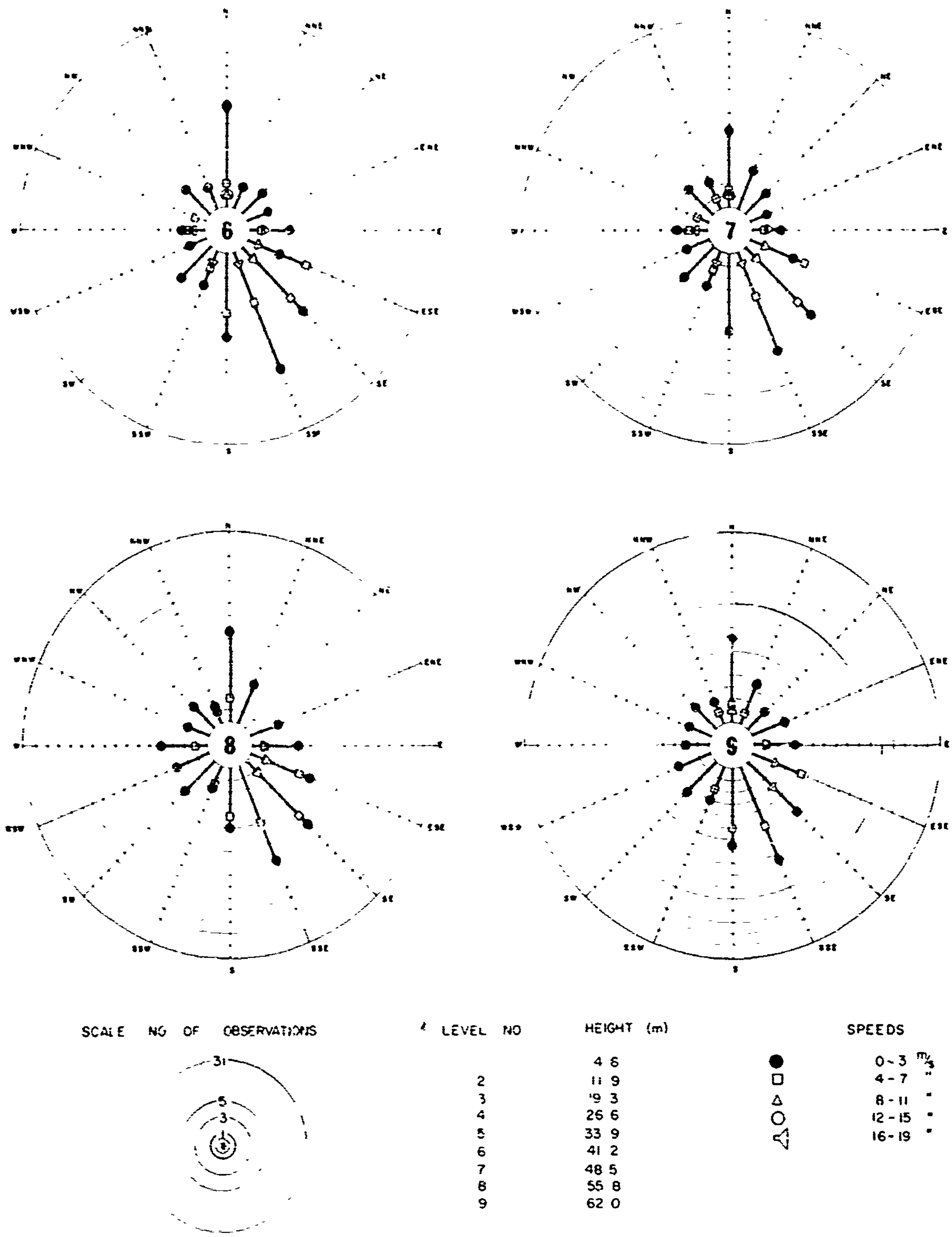


FIGURE 10 (CONT.): WIND ROSES (24 HOUR) FOR OCTOBER

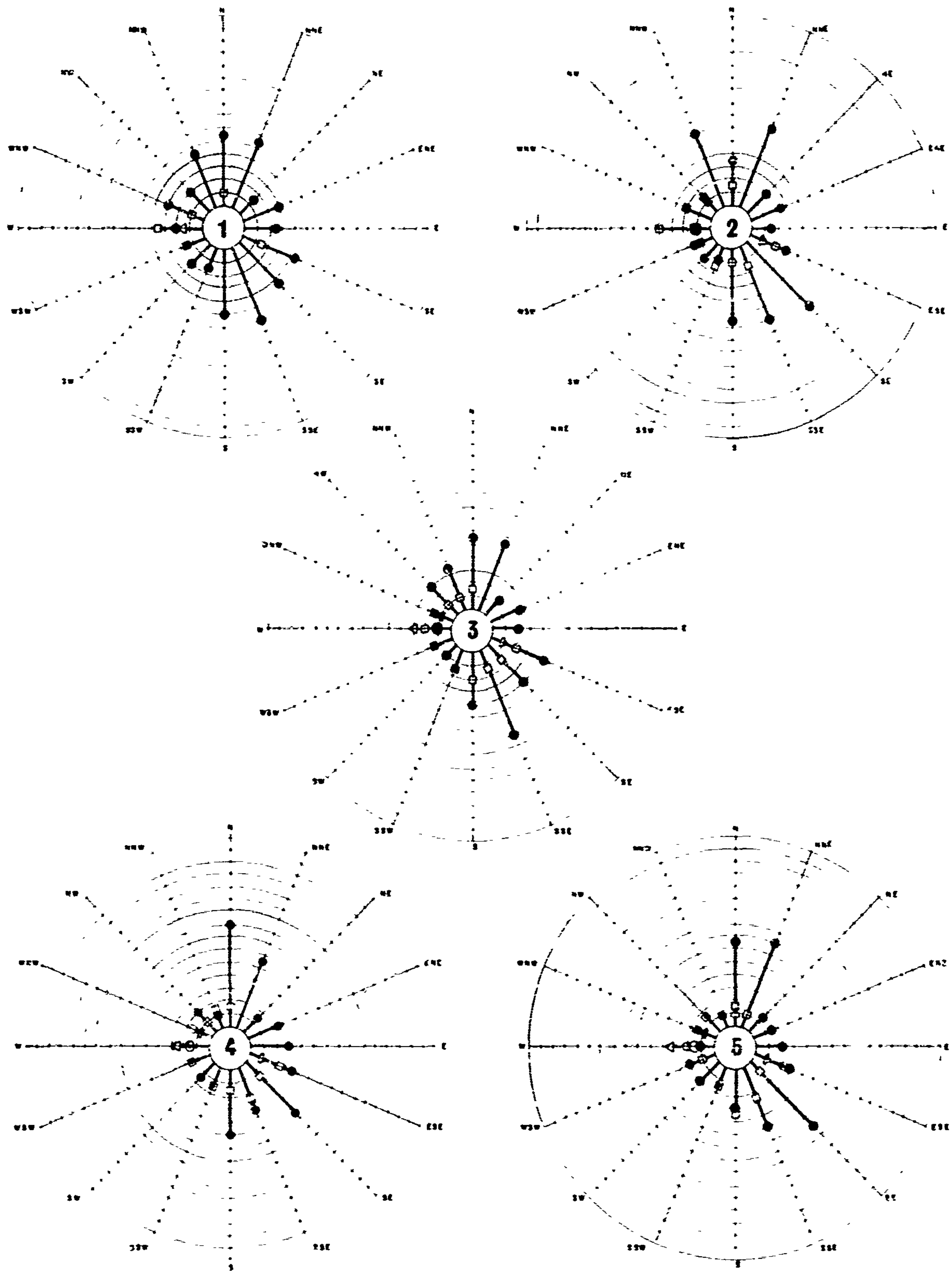
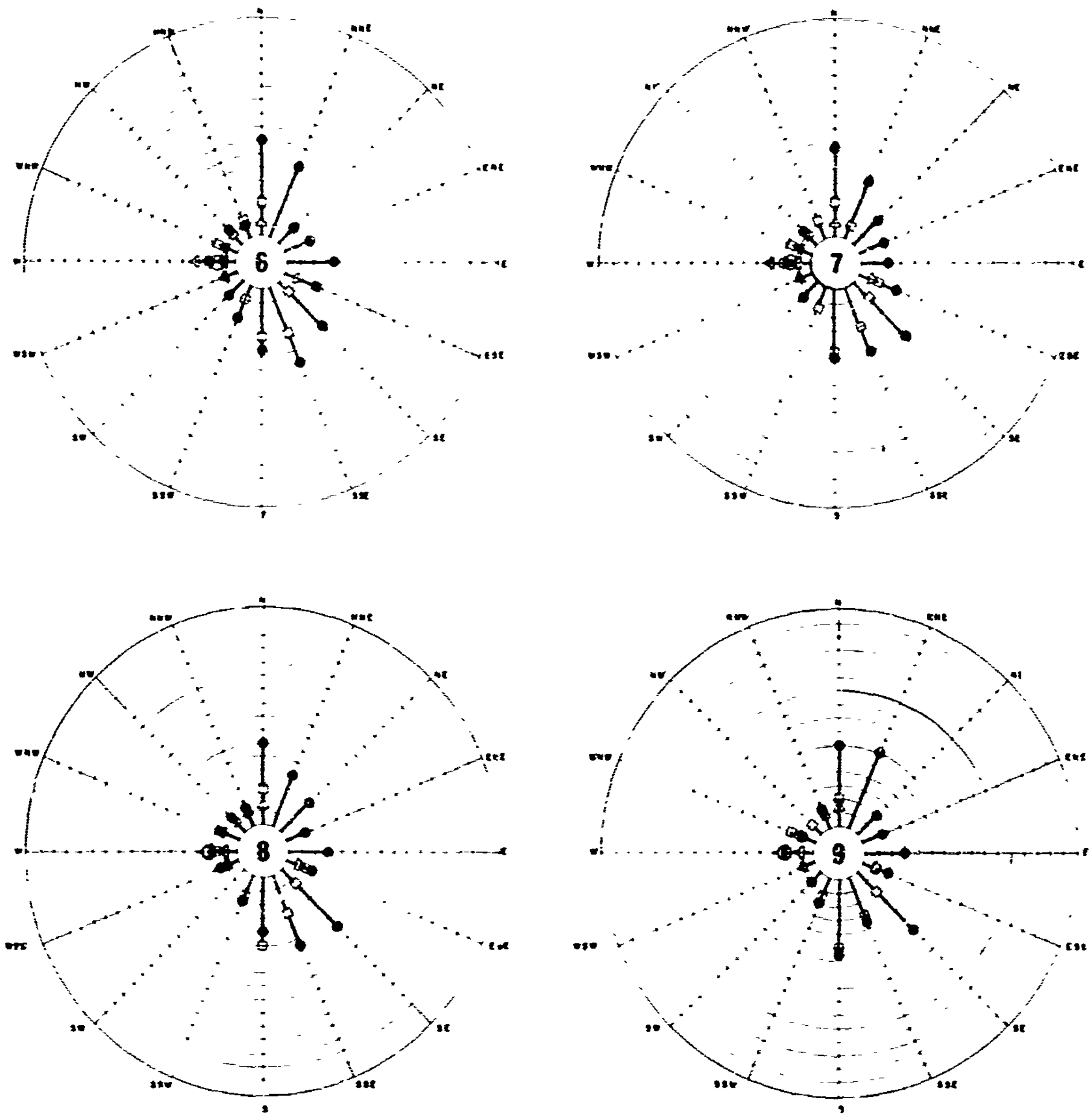
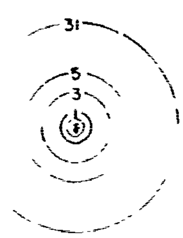


FIGURE 11: WIND ROSES (24 HOUR) FOR NOVEMBER



SCALE NO. OF OBSERVATIONS



* LEVEL NO.	HEIGHT (m)
1	4.6
2	11.3
3	19.3
4	26.6
5	33.9
6	41.2
7	48.5
8	55.8
9	62.0

SPEEDS	
●	0-3 m/s
□	4-7 "
△	8-11 "
○	12-15 "
◁	16-19 "

FIGURE 11 (CONT.): WIND ROSES (24 HOUR) FOR NOVEMBER

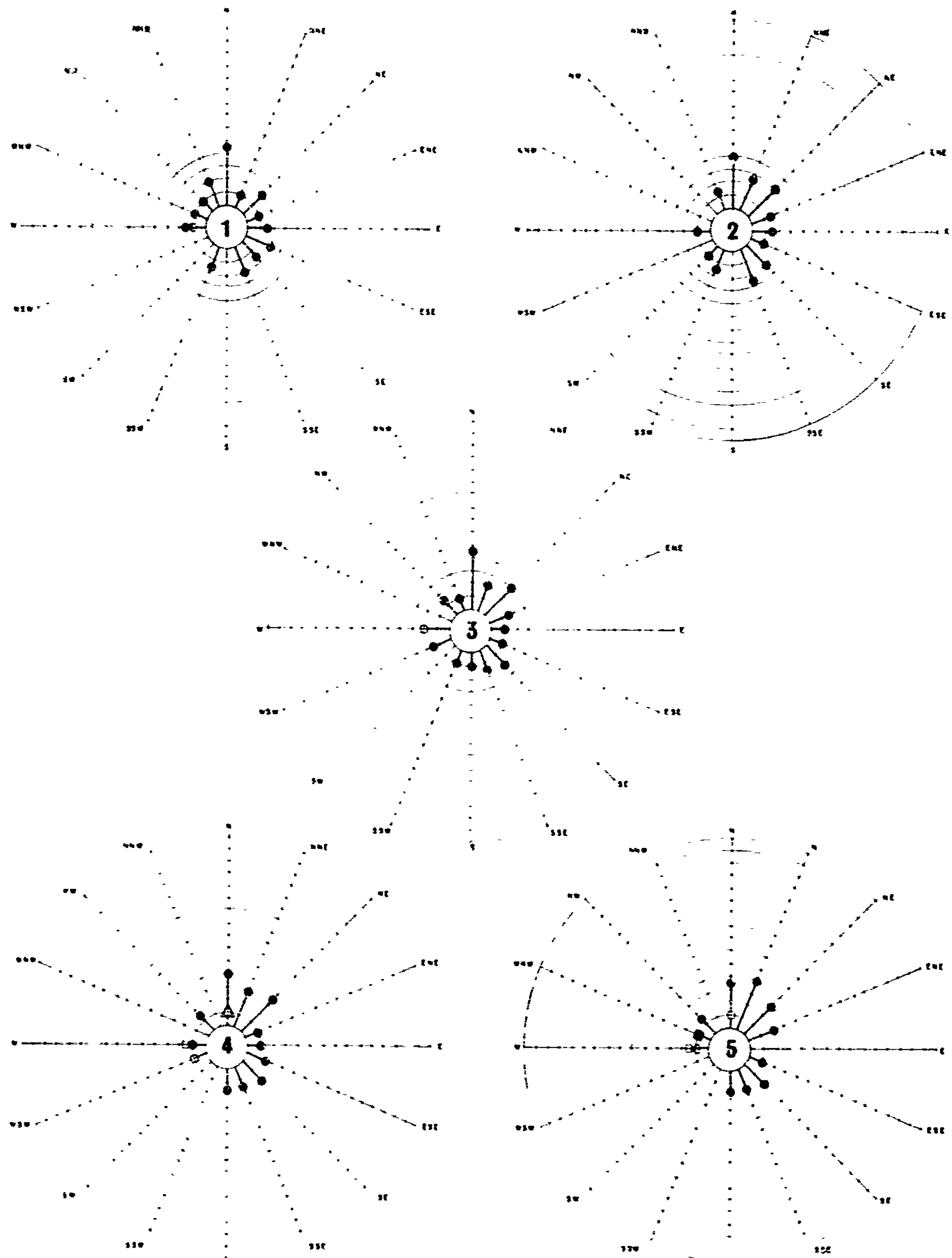


FIGURE 12: WIND ROSES (24 HOUR) FOR DECEMBER

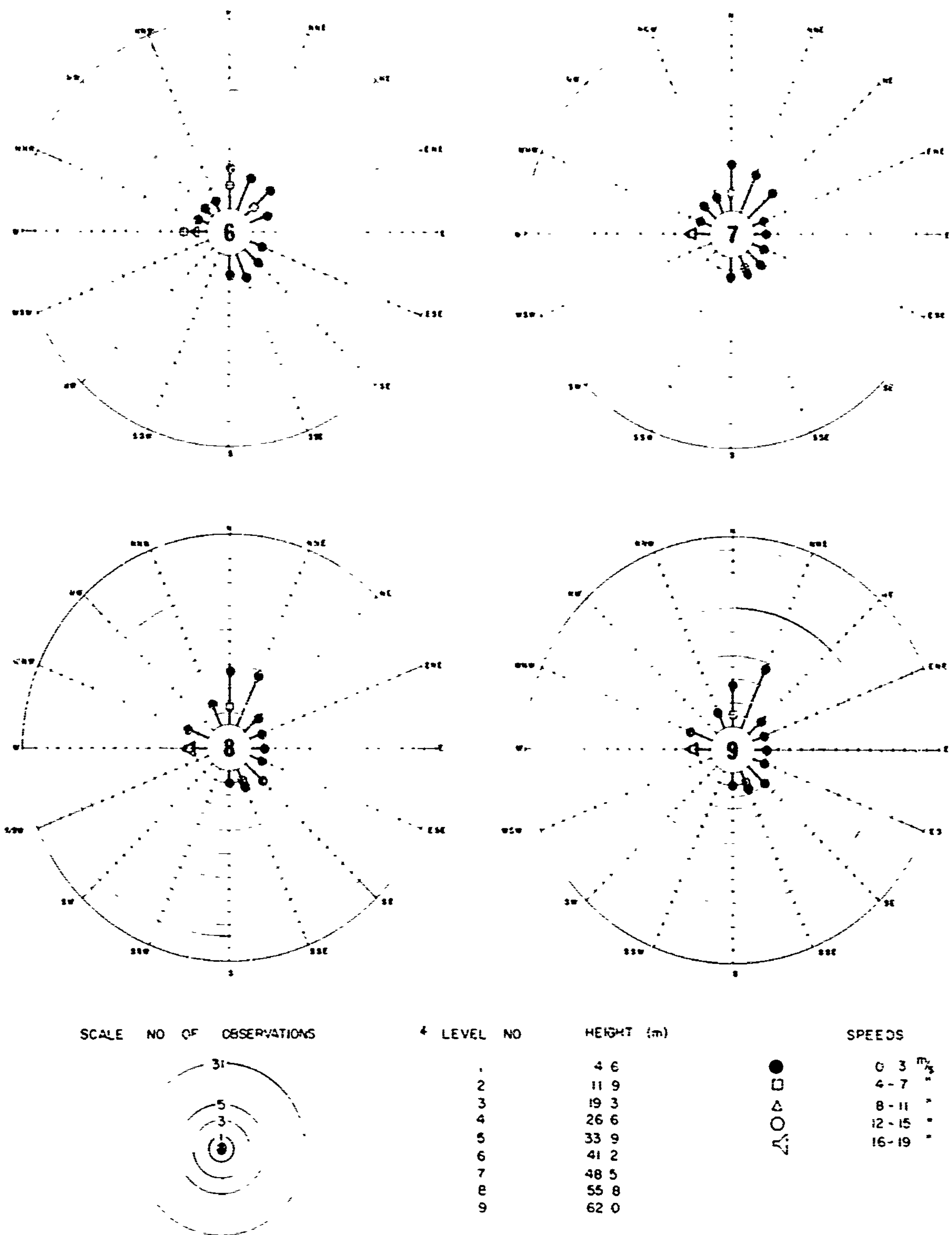


FIGURE 12 (CONT.): WIND ROSES (24 HOUR) FOR DECEMBER

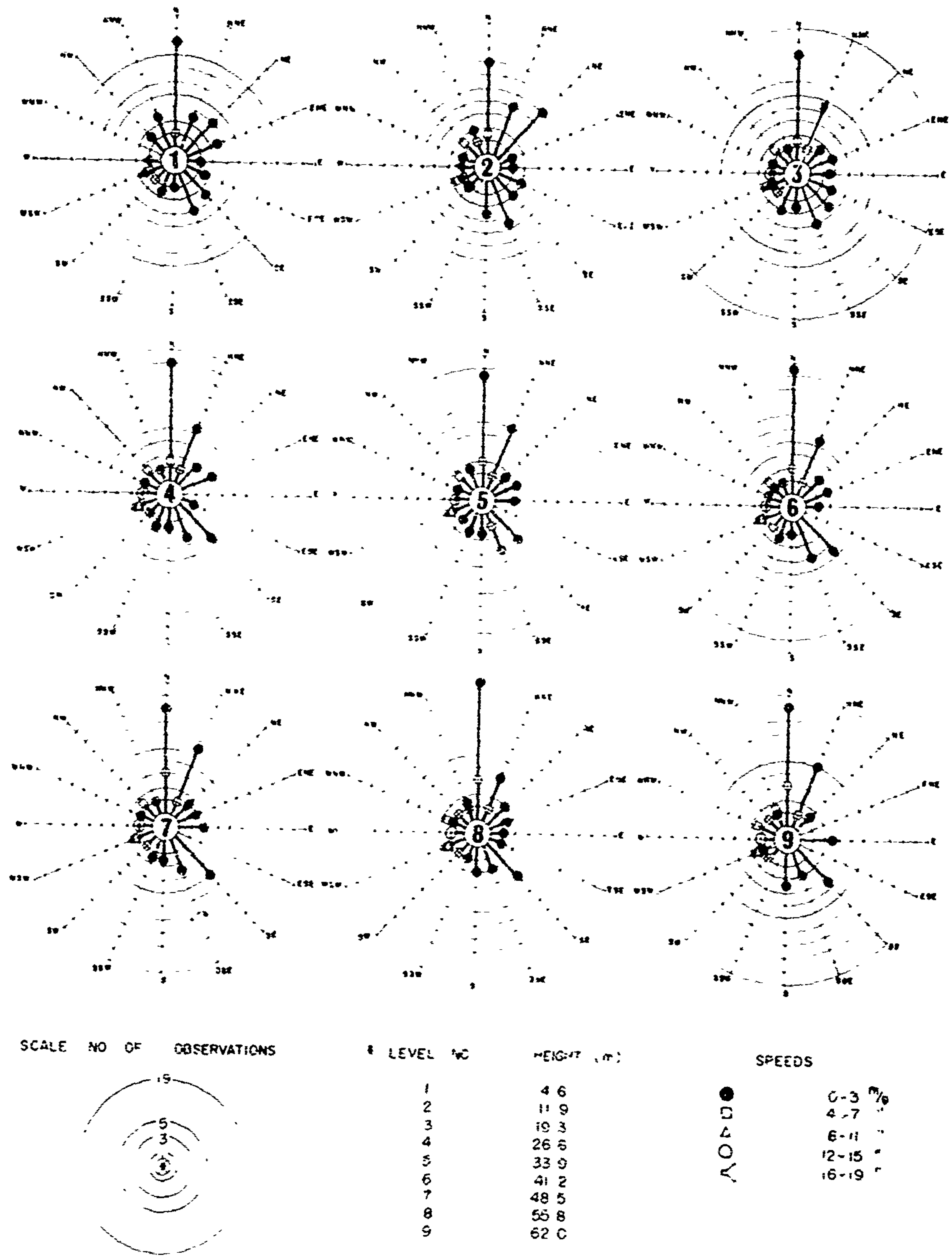


FIGURE 13 : DAYTIME WIND ROSES FOR JANUARY

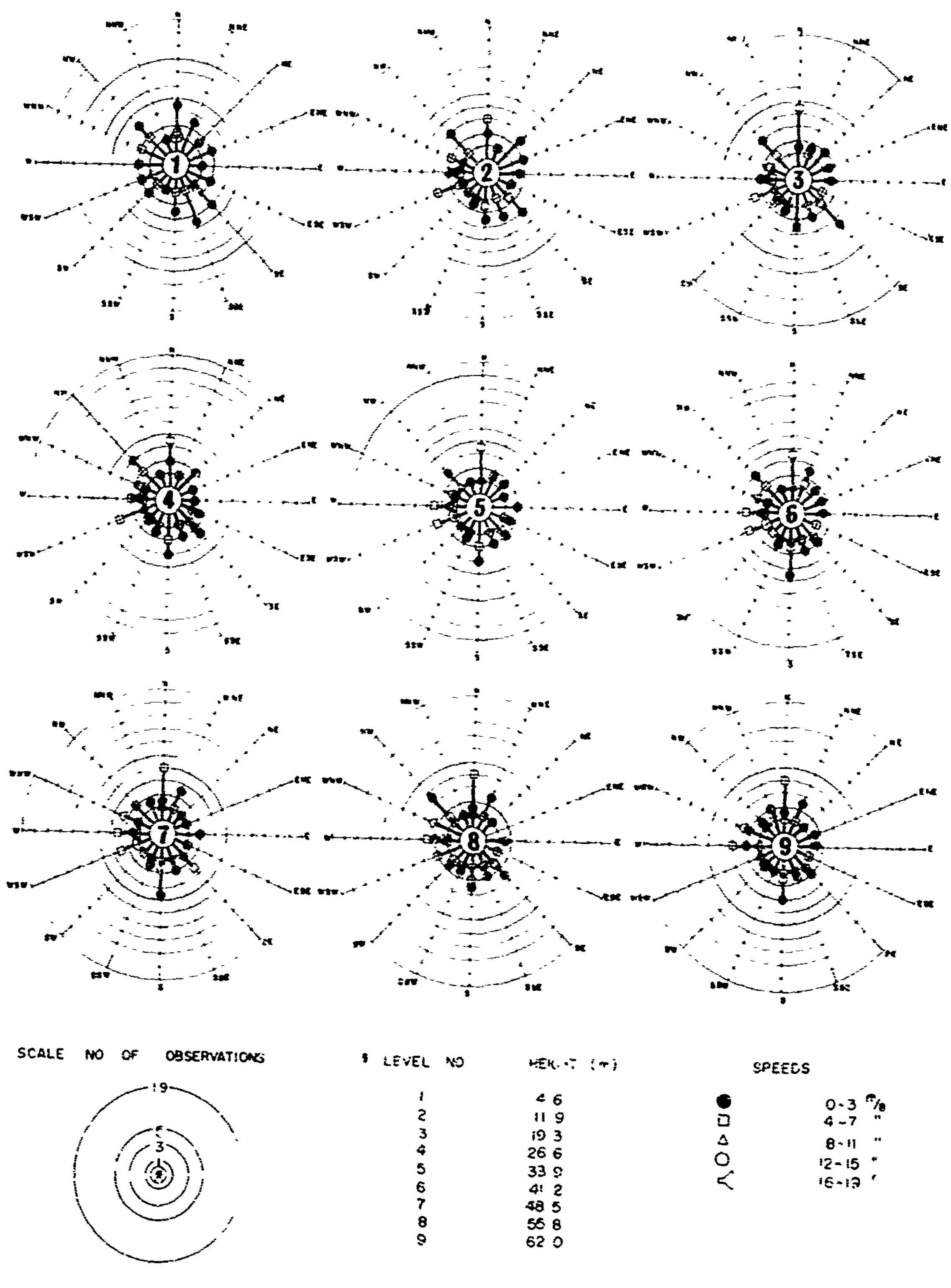


FIGURE 14 : DAYTIME WIND ROSES FOR FEBRUARY

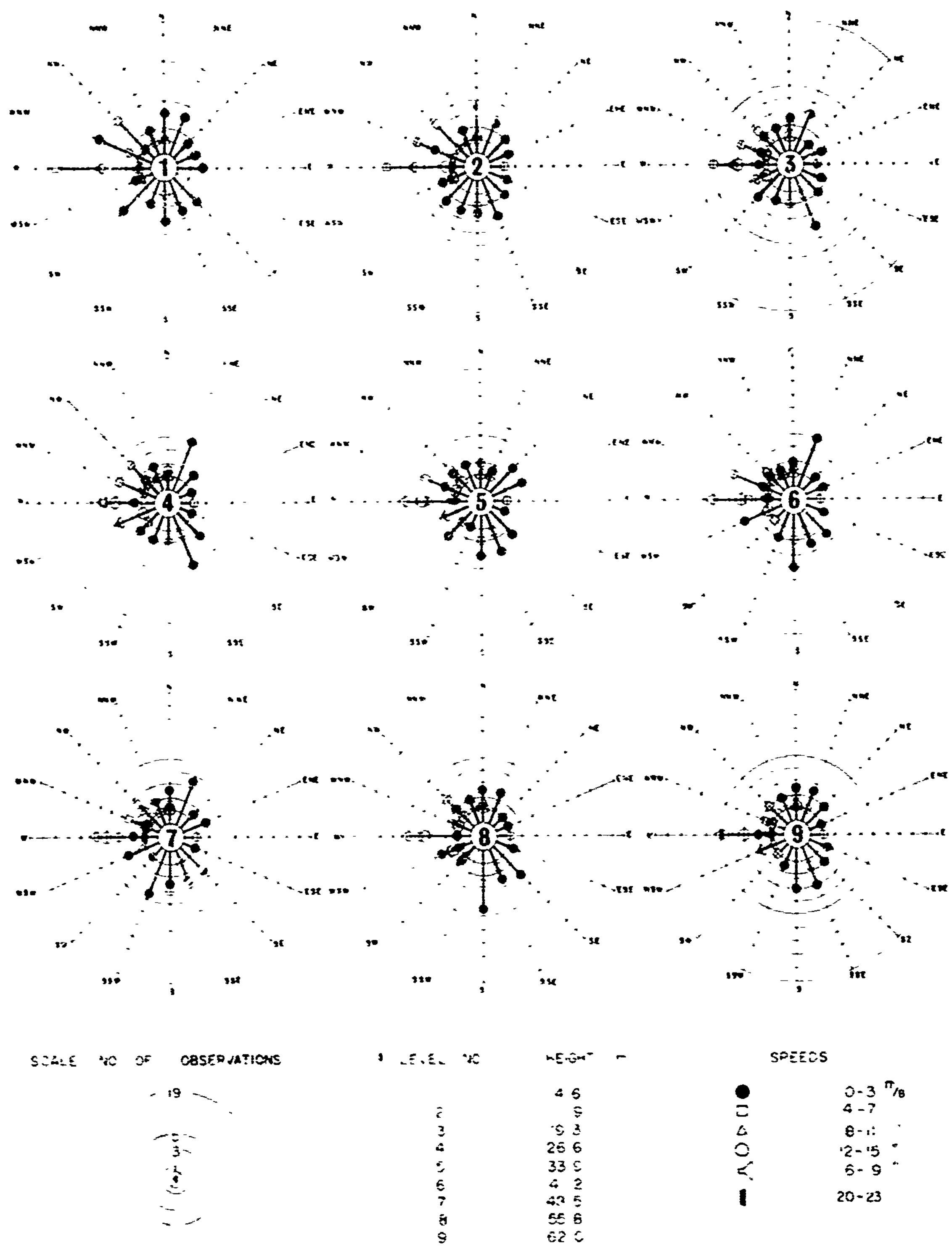


FIGURE I5 : DAYTIME WIND ROSES FOR MARCH

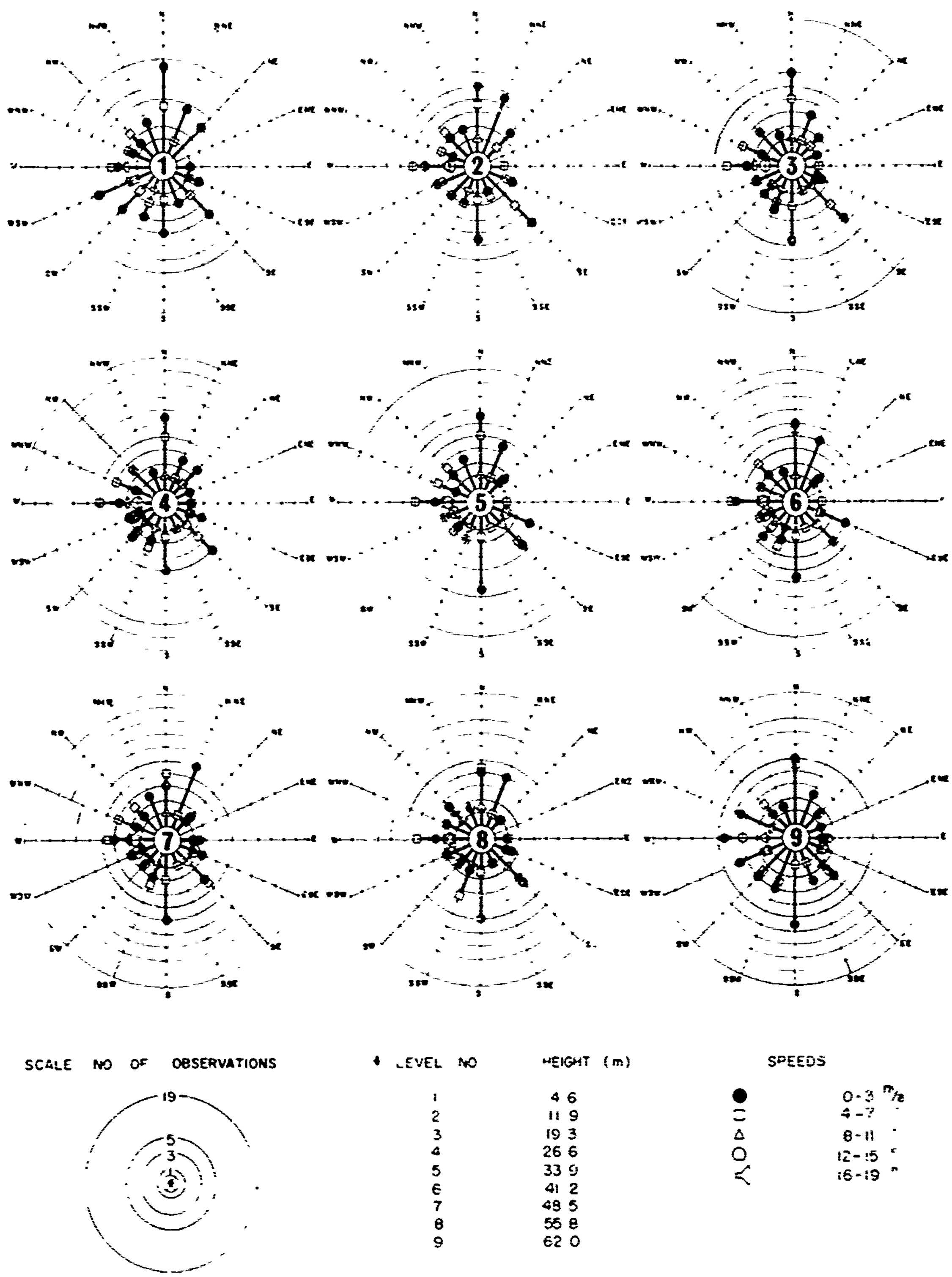


FIGURE 16 : DAYTIME WIND ROSES FOR APRIL

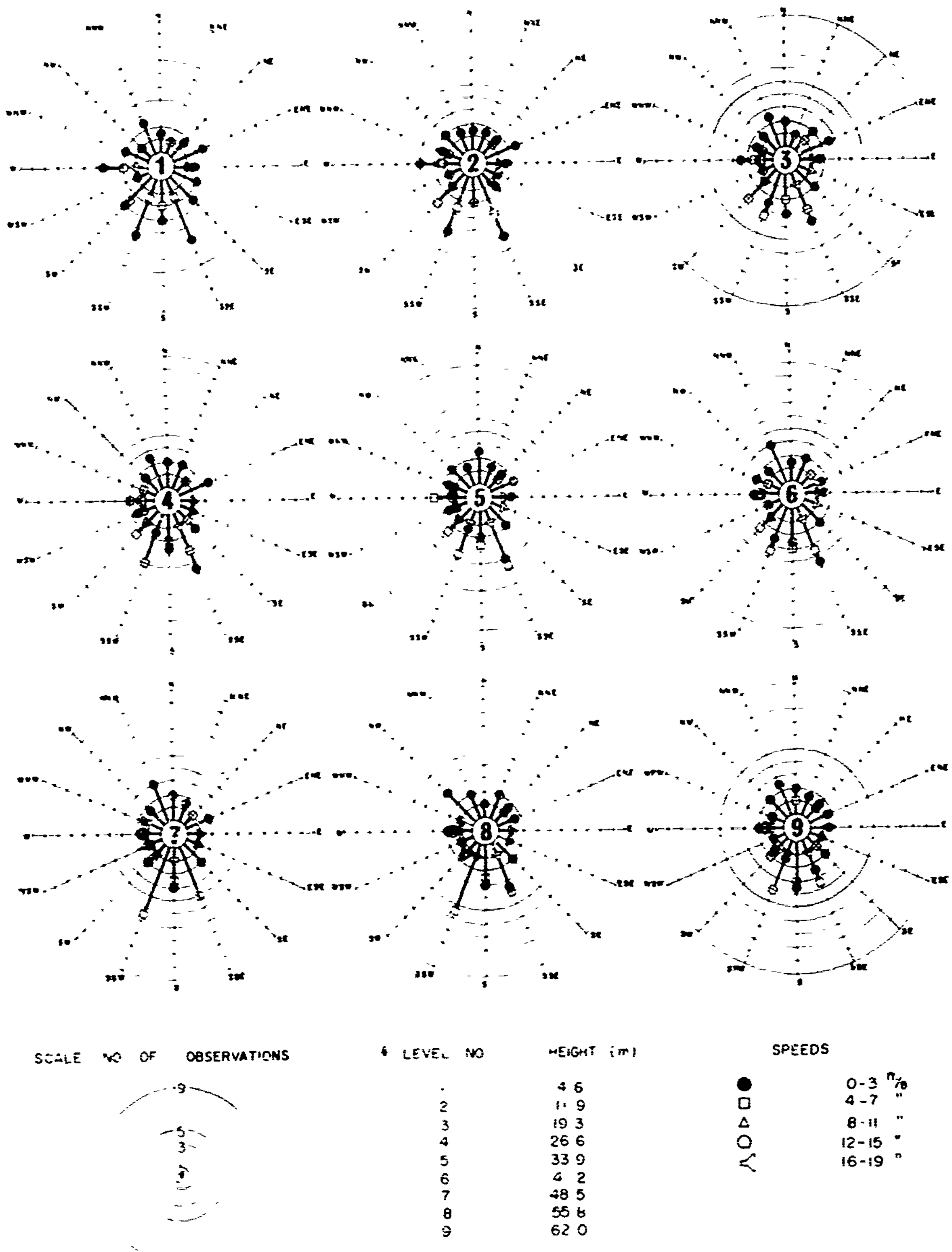


FIGURE 17: DAYTIME WIND ROSES FOR MAY

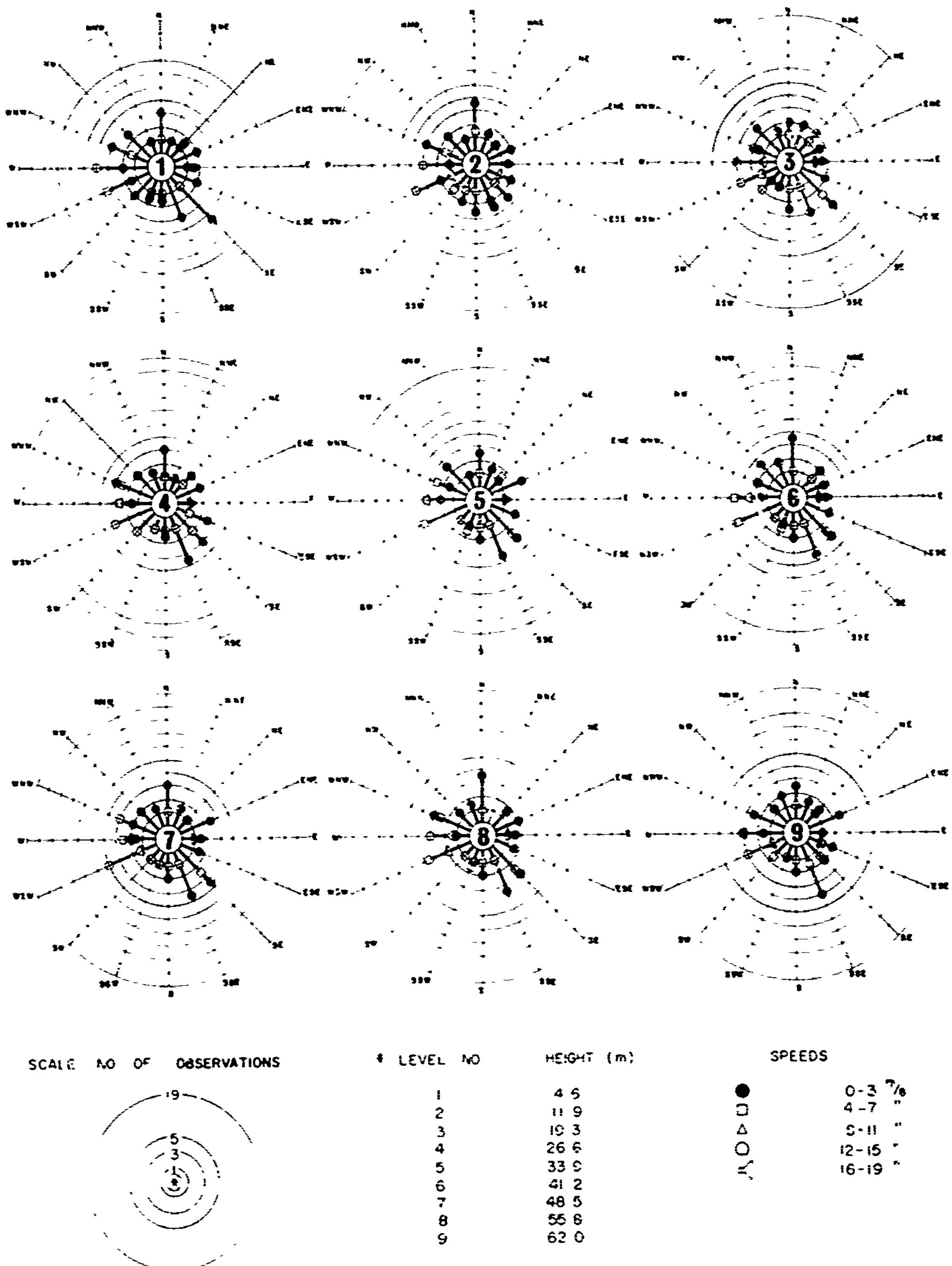


FIGURE 18: DAYTIME WIND ROSES FOR JUNE

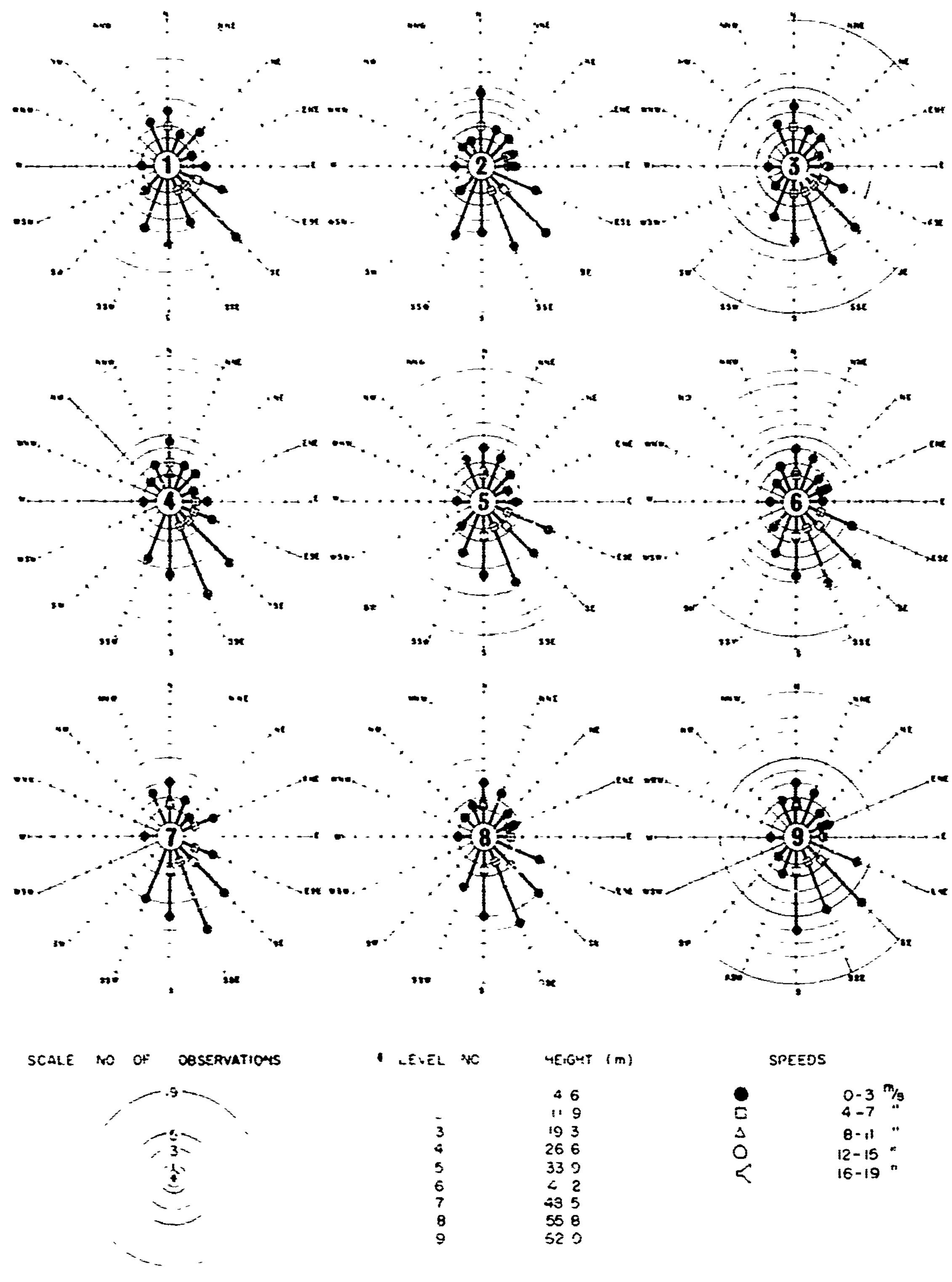


FIGURE 19: DAYTIME WIND ROSES FOR JULY

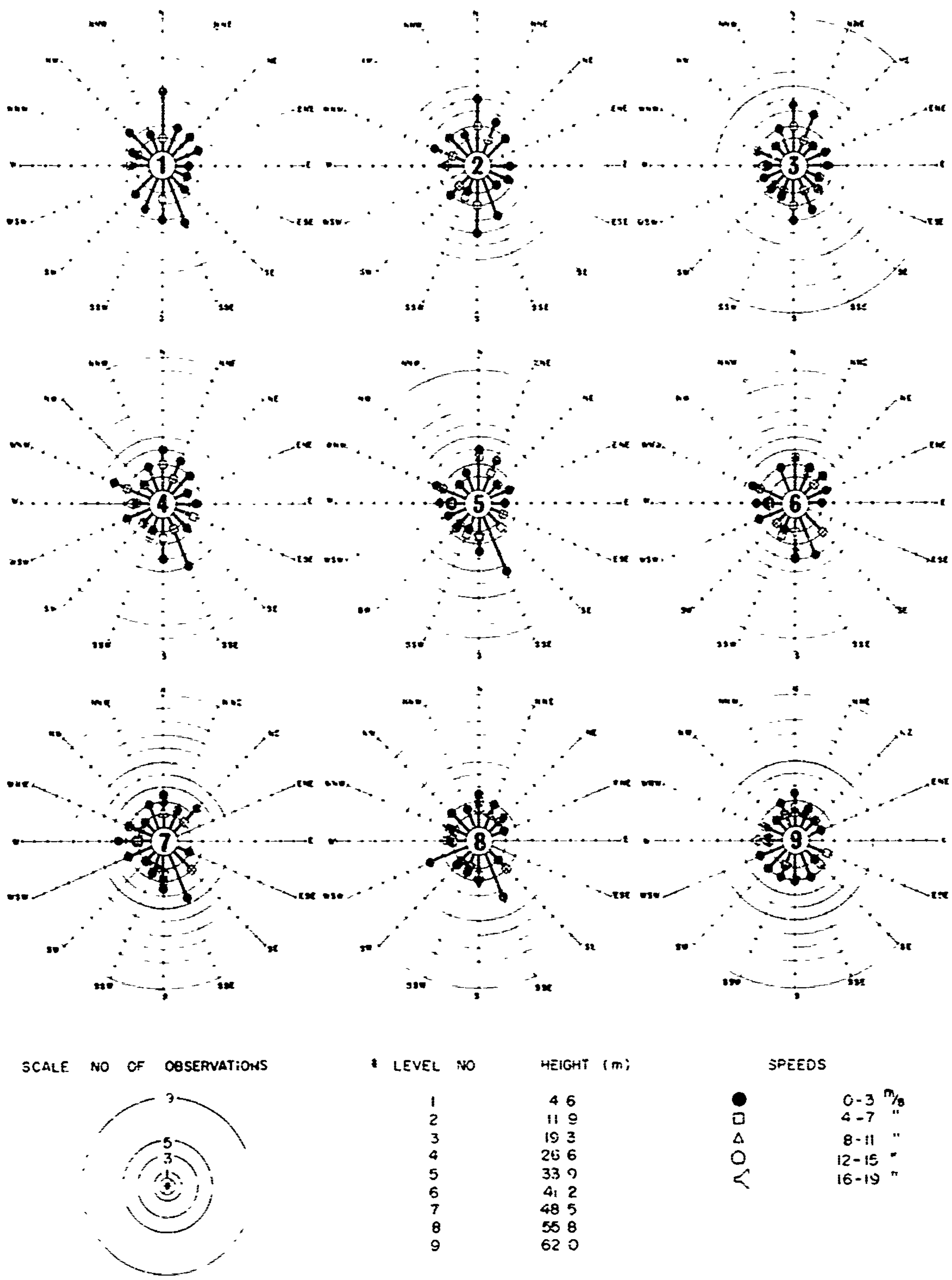


FIGURE 20: DAYTIME WIND ROSES FOR AUGUST

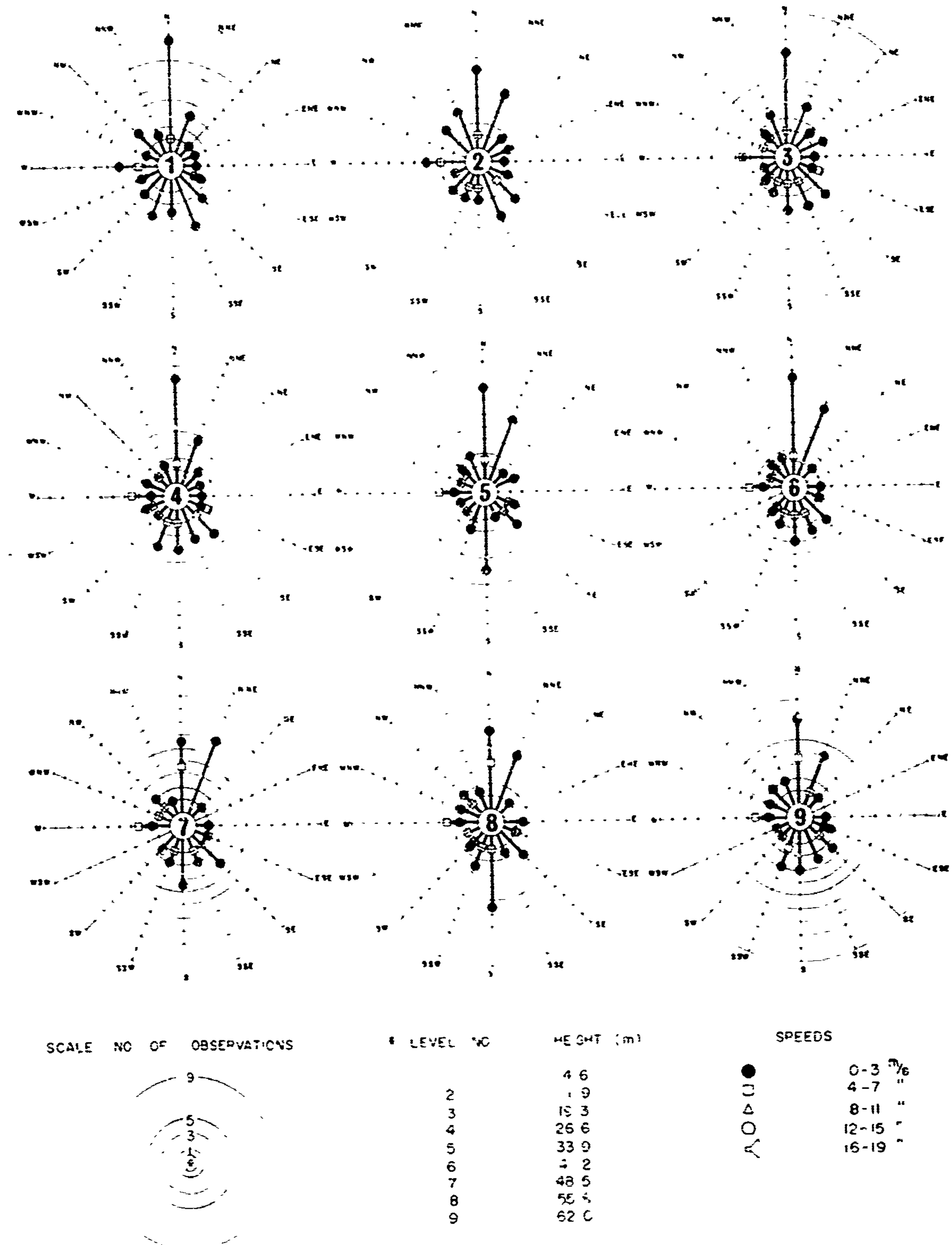


FIGURE 21: DAYTIME WIND ROSES FOR SEPTEMBER

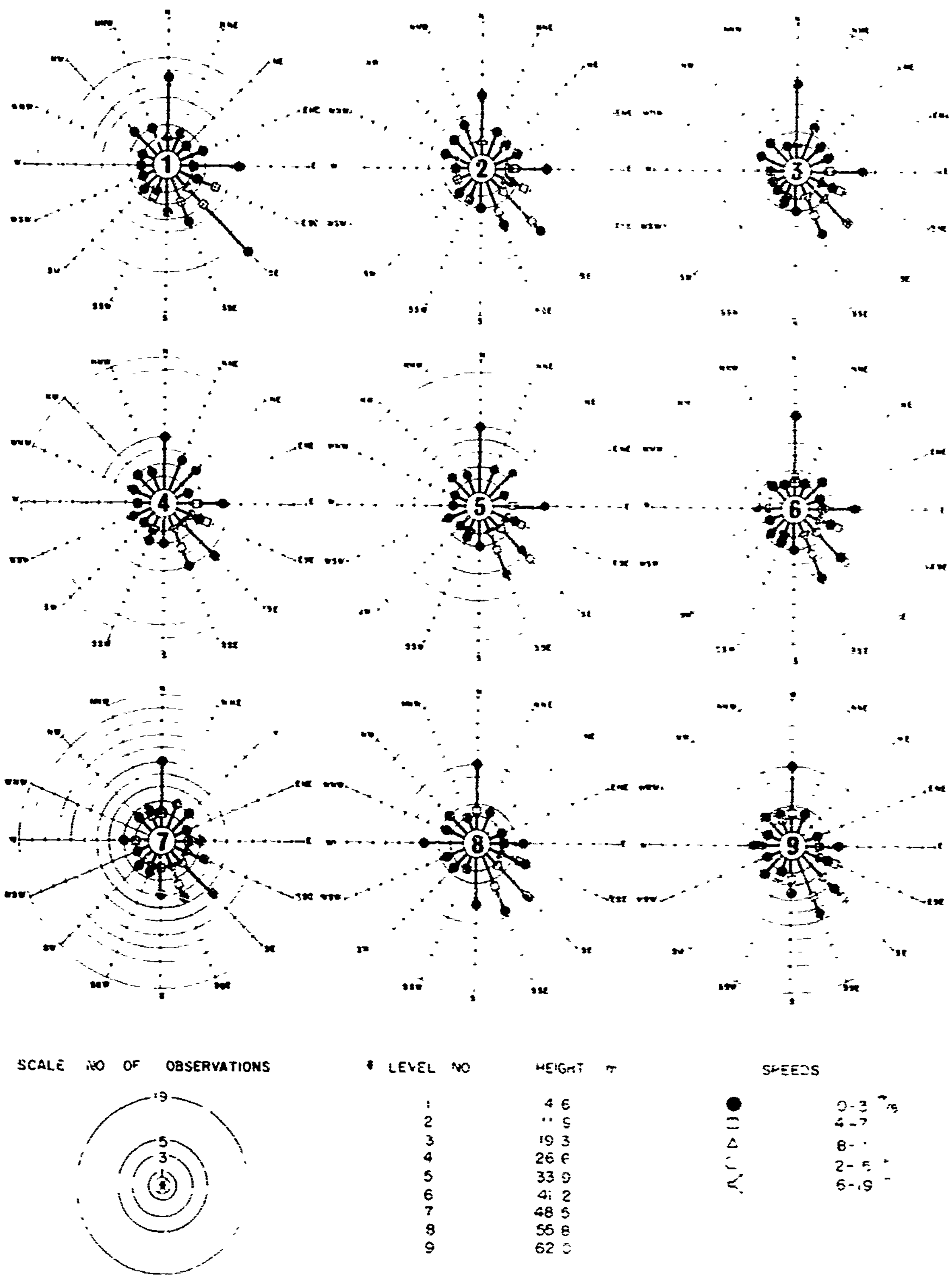


FIGURE 22: DAYTIME WIND ROSES FOR OCTOBER

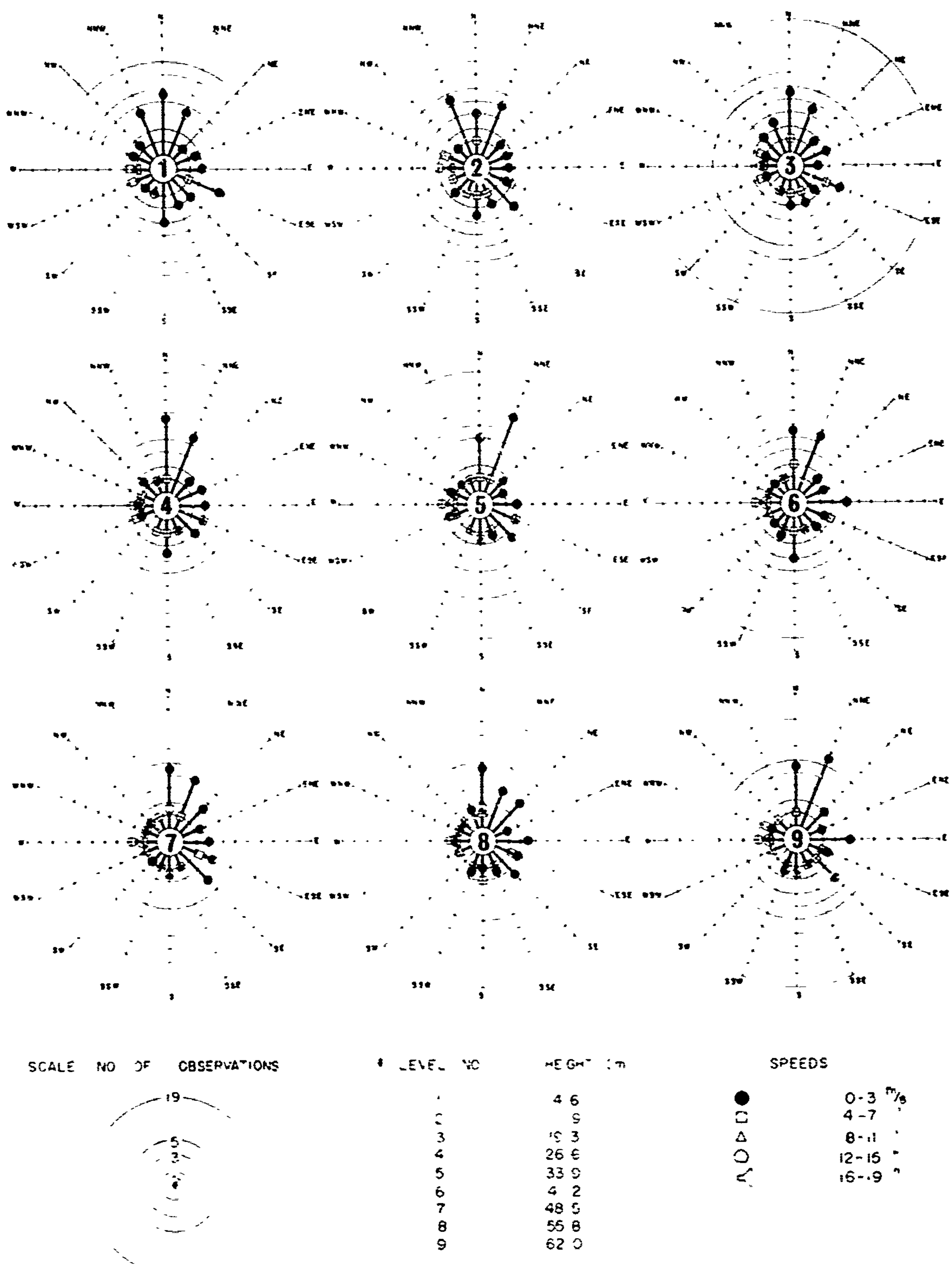


FIGURE 23: DAYTIME WIND ROSES FOR NOVEMBER

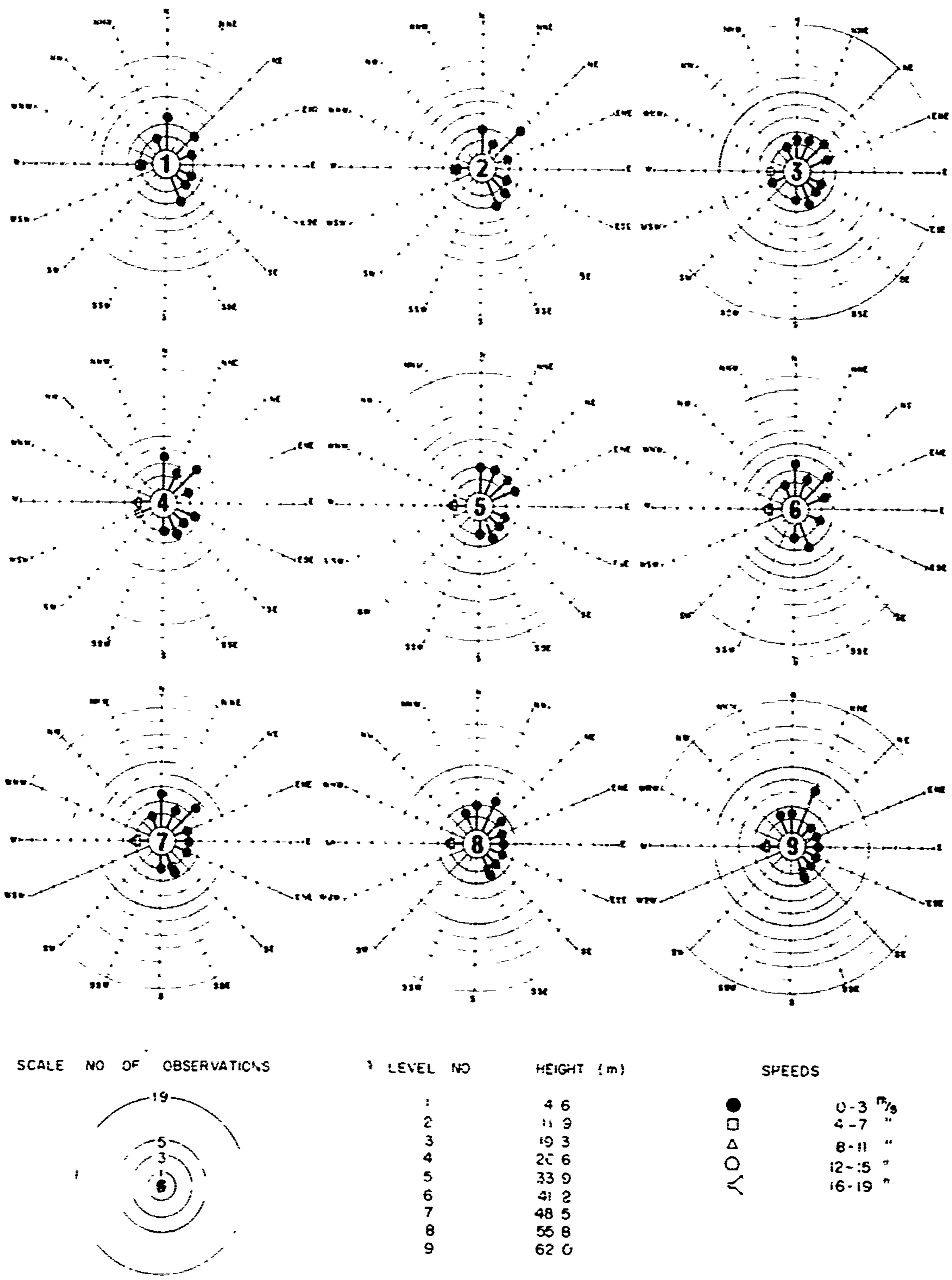


FIGURE 24: DAYTIME WIND ROSES FOR DECEMBER

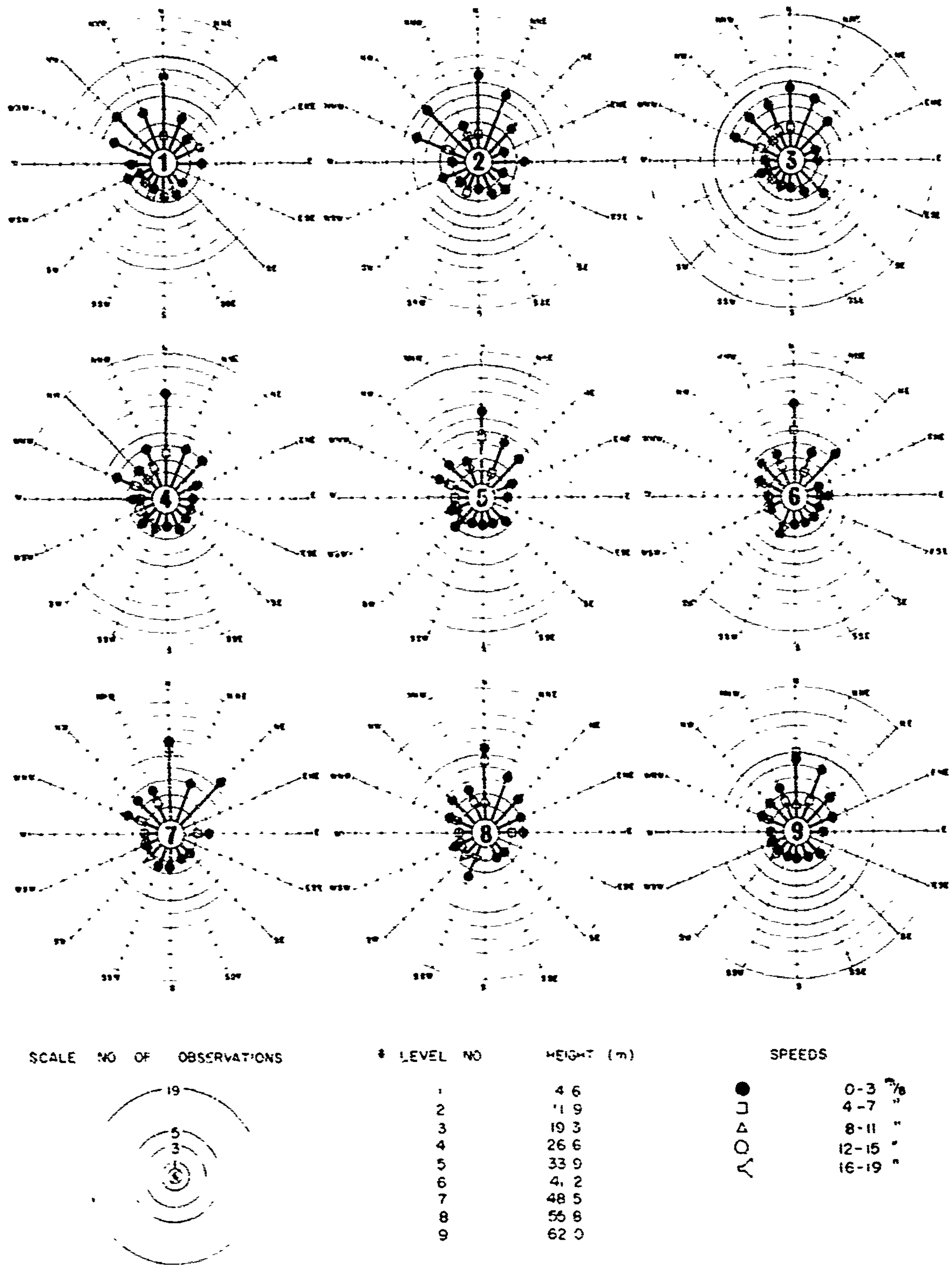
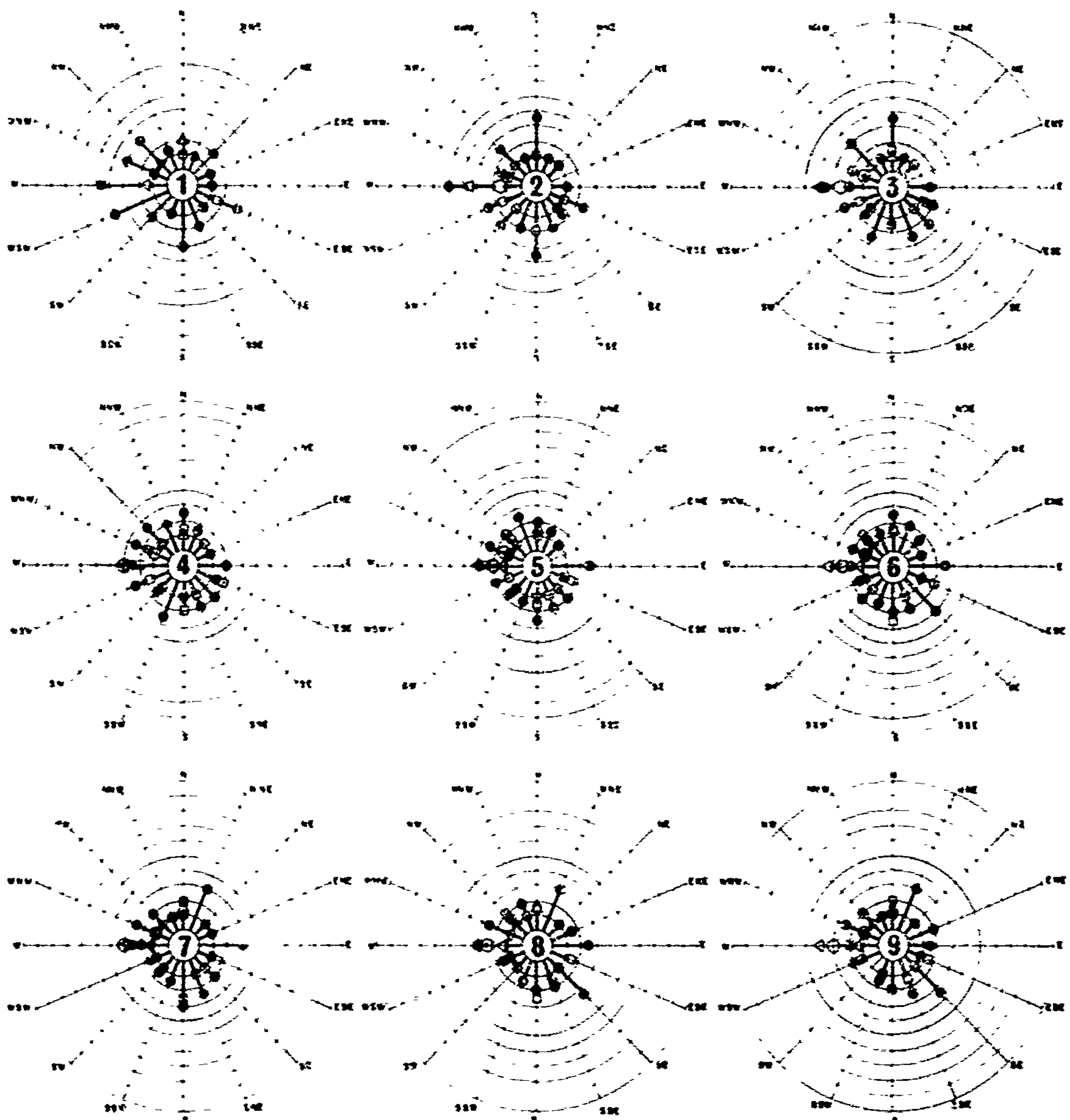
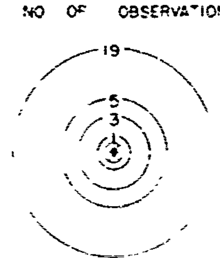


FIGURE 25: NIGHTTIME WIND ROSES FOR JANUARY



SCALE NO OF OBSERVATIONS



# LEVEL NO	HEIGHT (m)
1	4.6
2	11.9
3	19.3
4	26.6
5	33.9
6	41.2
7	48.5
8	55.8
9	62.0

SPEEDS

●	0-3 m/s
□	4-7 "
△	8-11 "
○	12-15 "
<	16-19 "

FIGURE 26: NIGHTTIME WIND ROSES FOR FEBRUARY

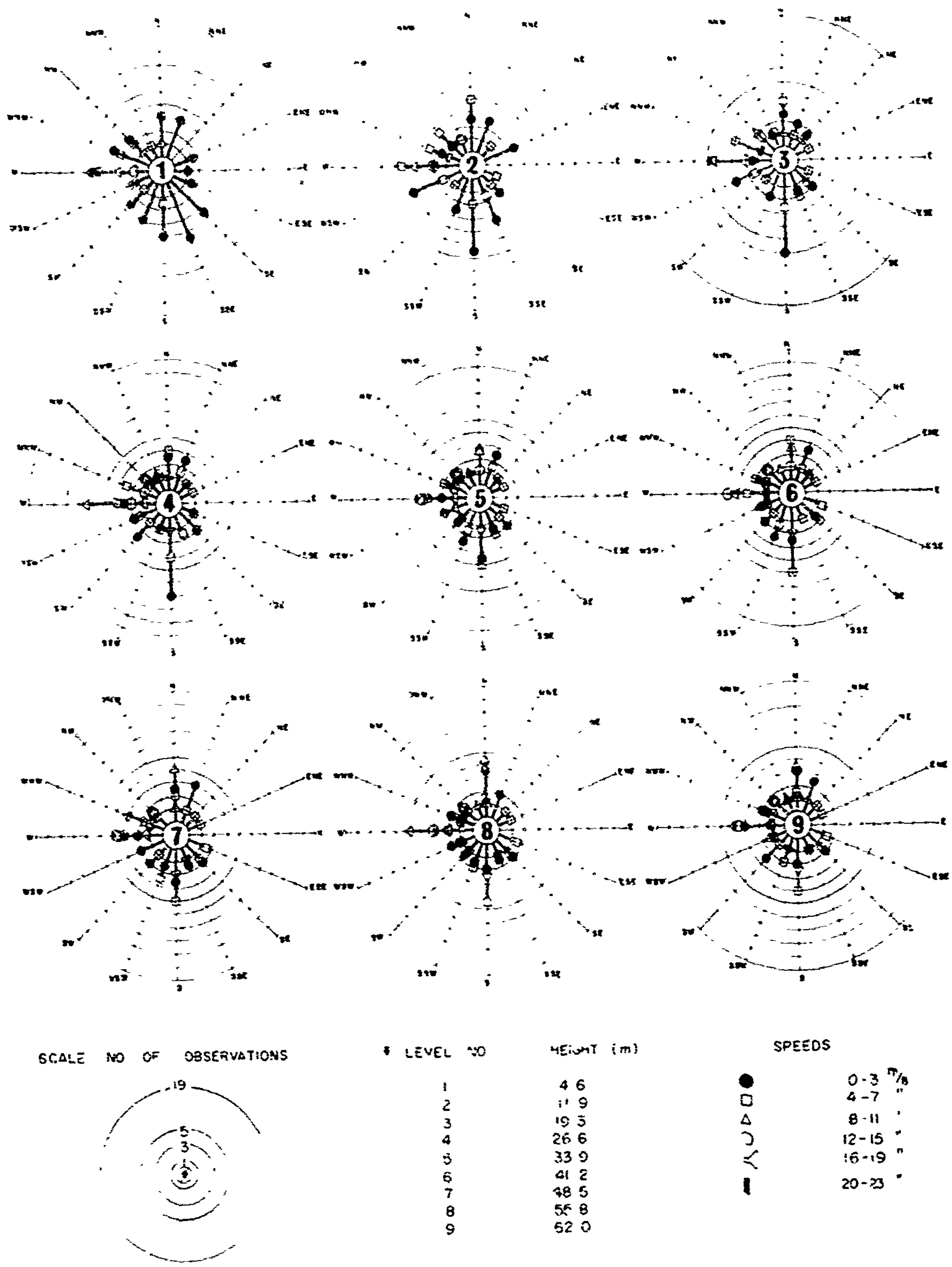


FIGURE 27 NIGHTTIME WIND ROSES FOR MARCH

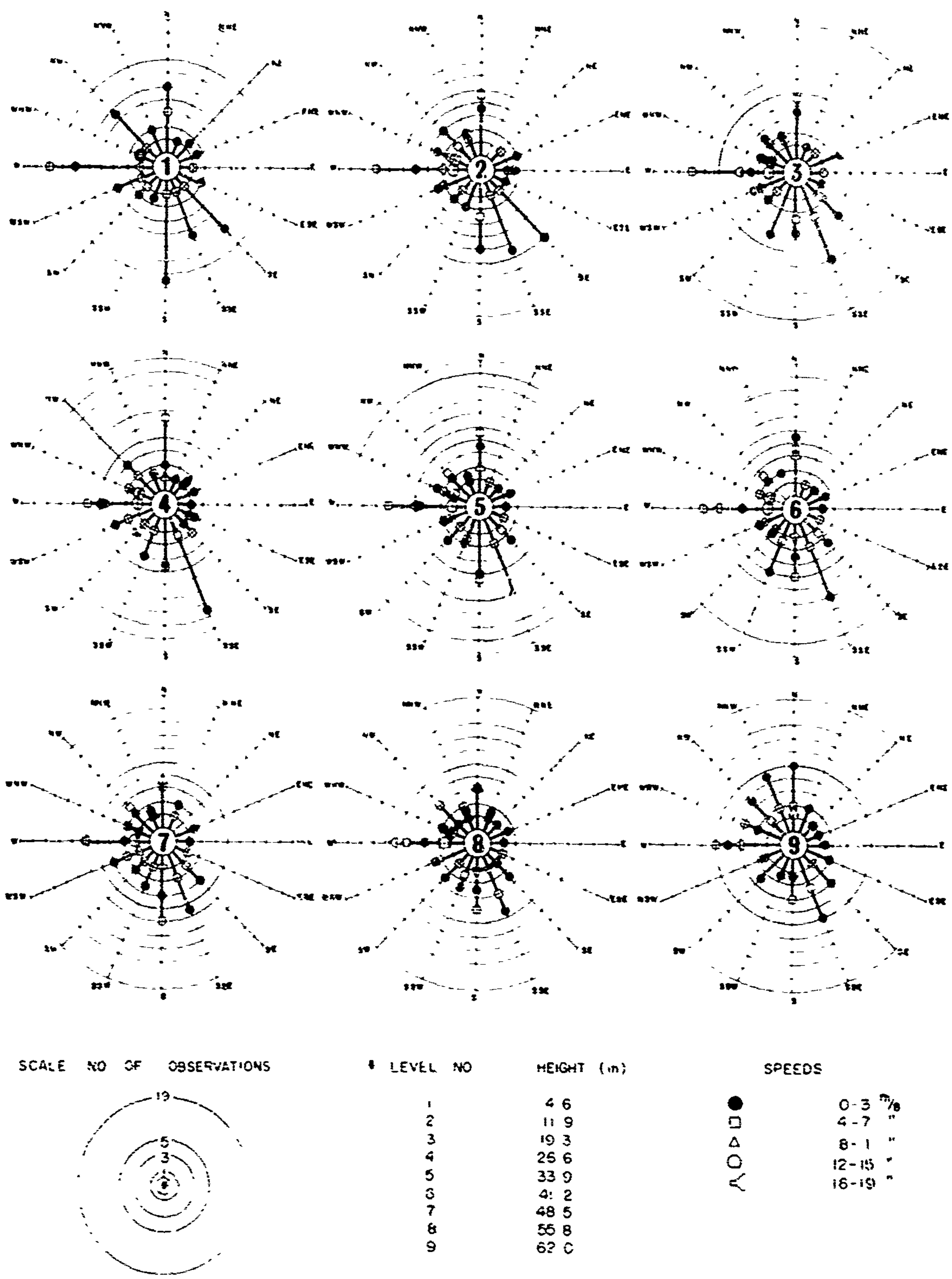


FIGURE 28: NIGHTTIME WIND ROSES FOR APRIL

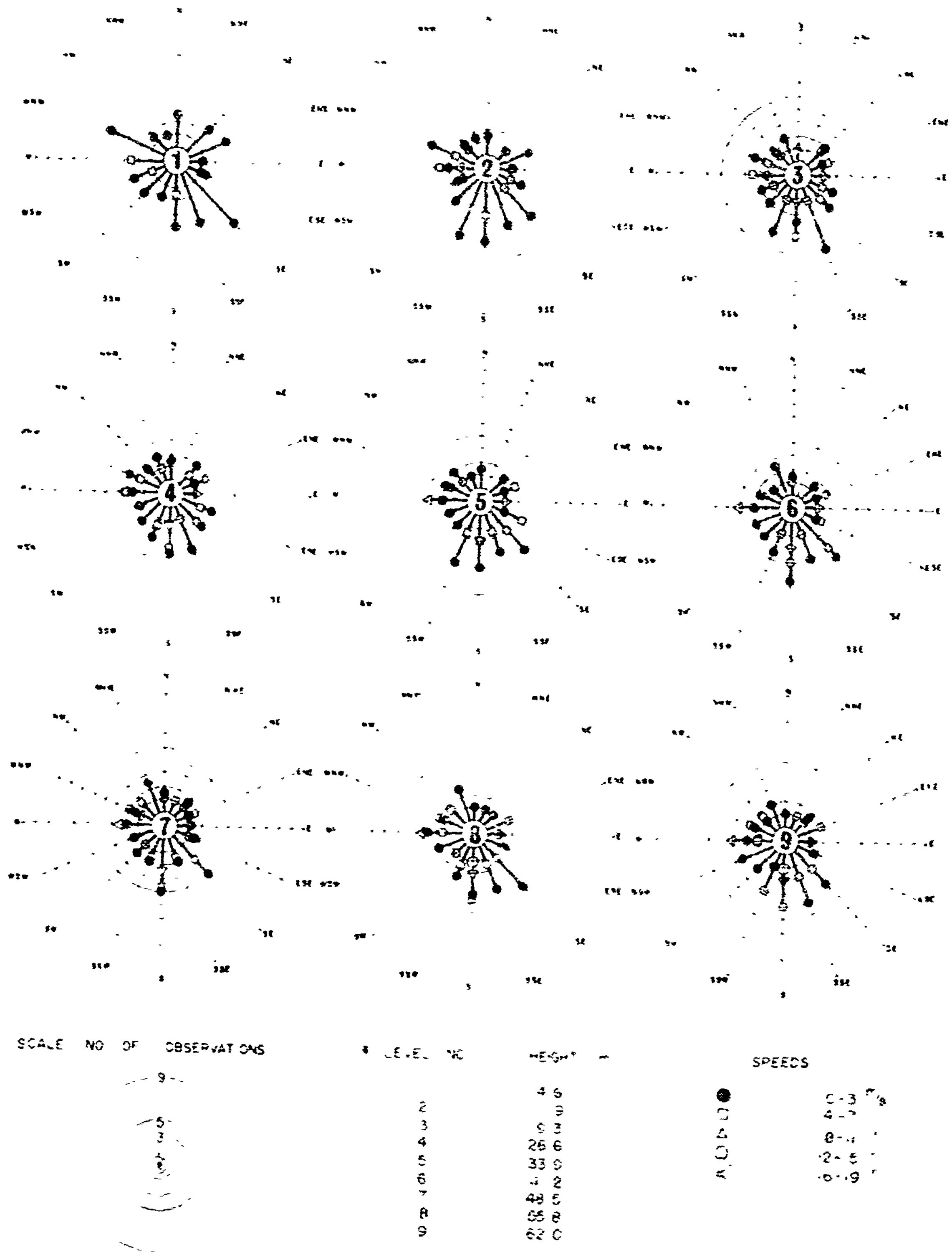


FIGURE 29. NIGHTTIME WIND ROSES FOR MAY

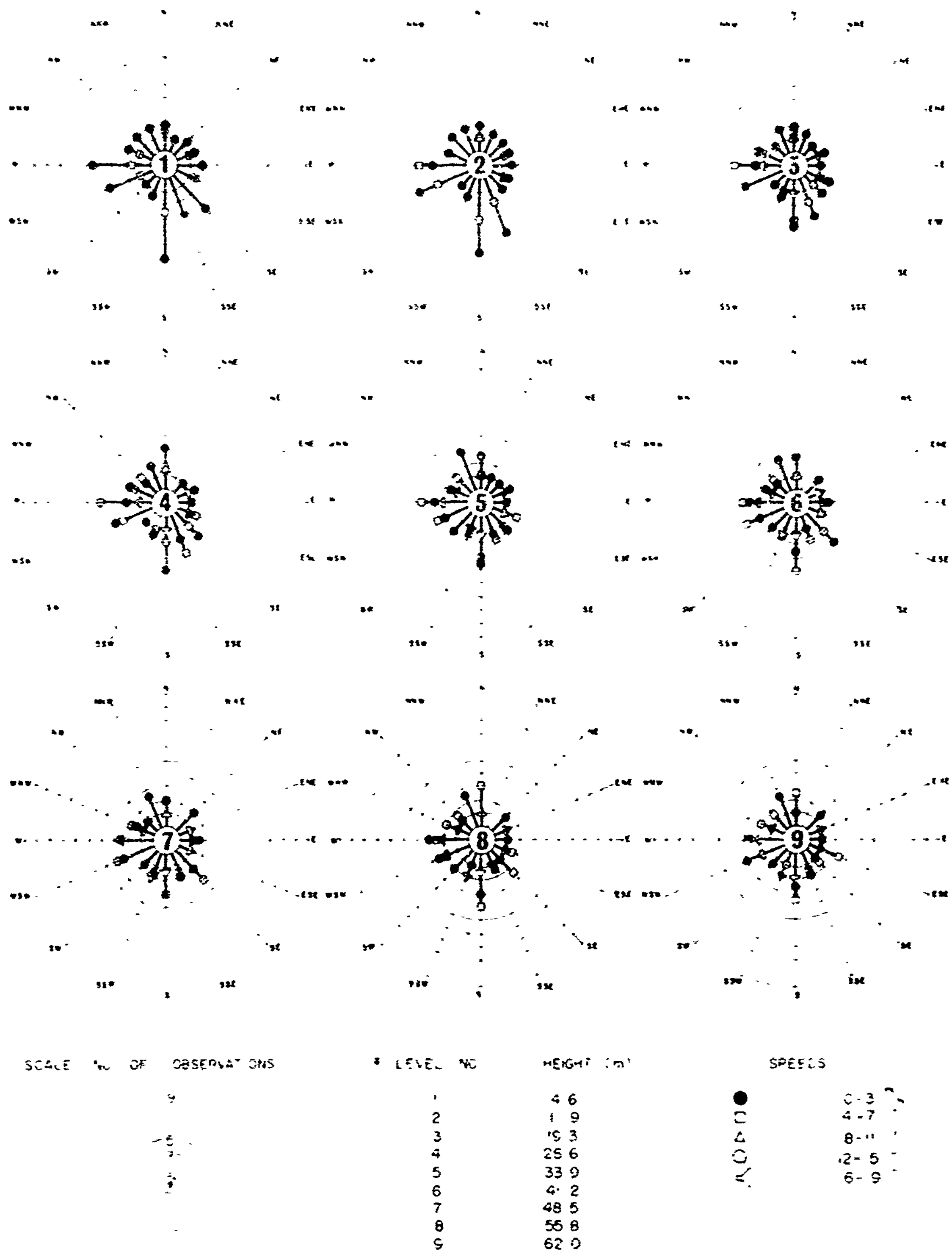


FIGURE 30: NIGHTTIME WIND ROSES FOR JUNE

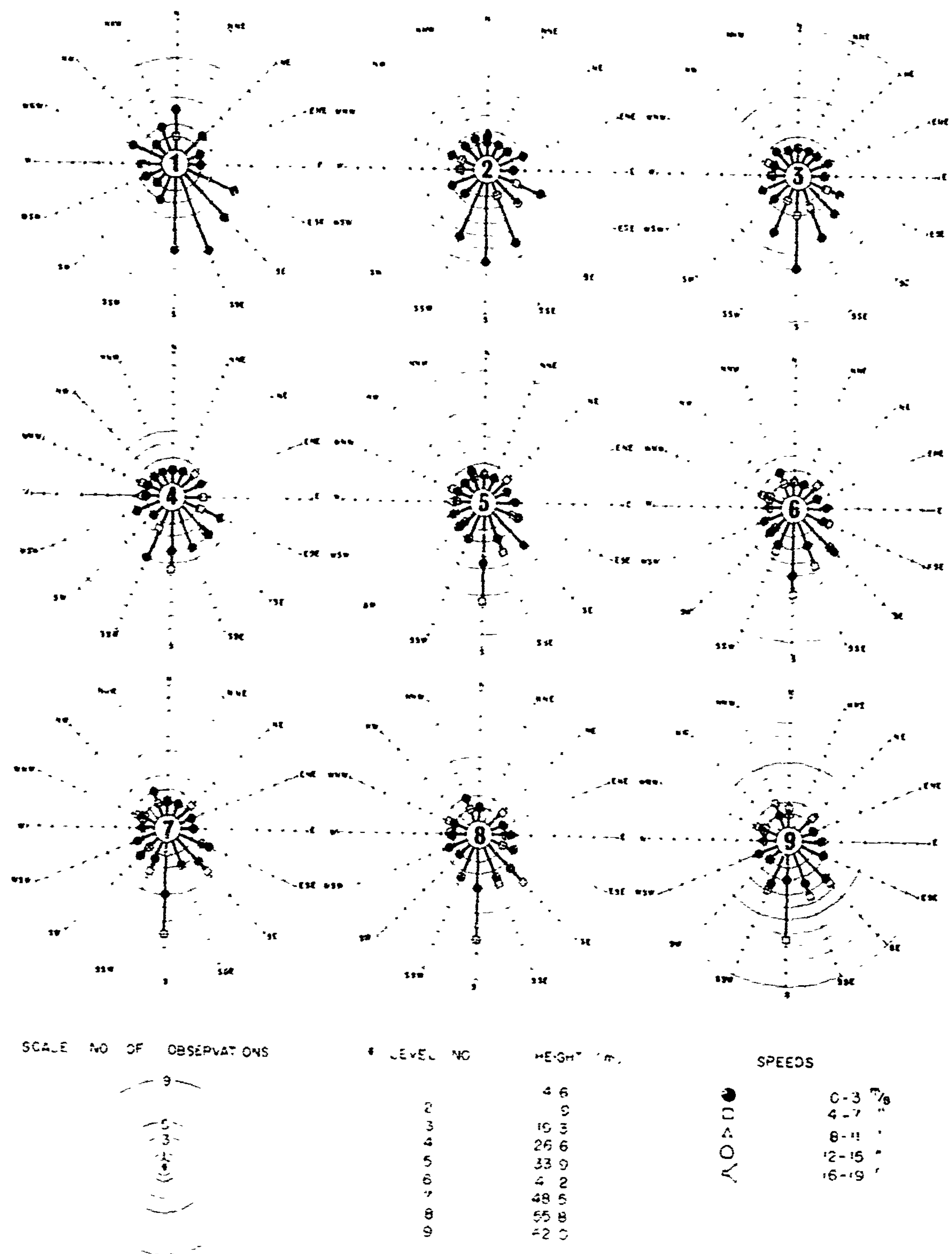


FIGURE 31: NIGHTTIME WIND ROSES FOR JULY

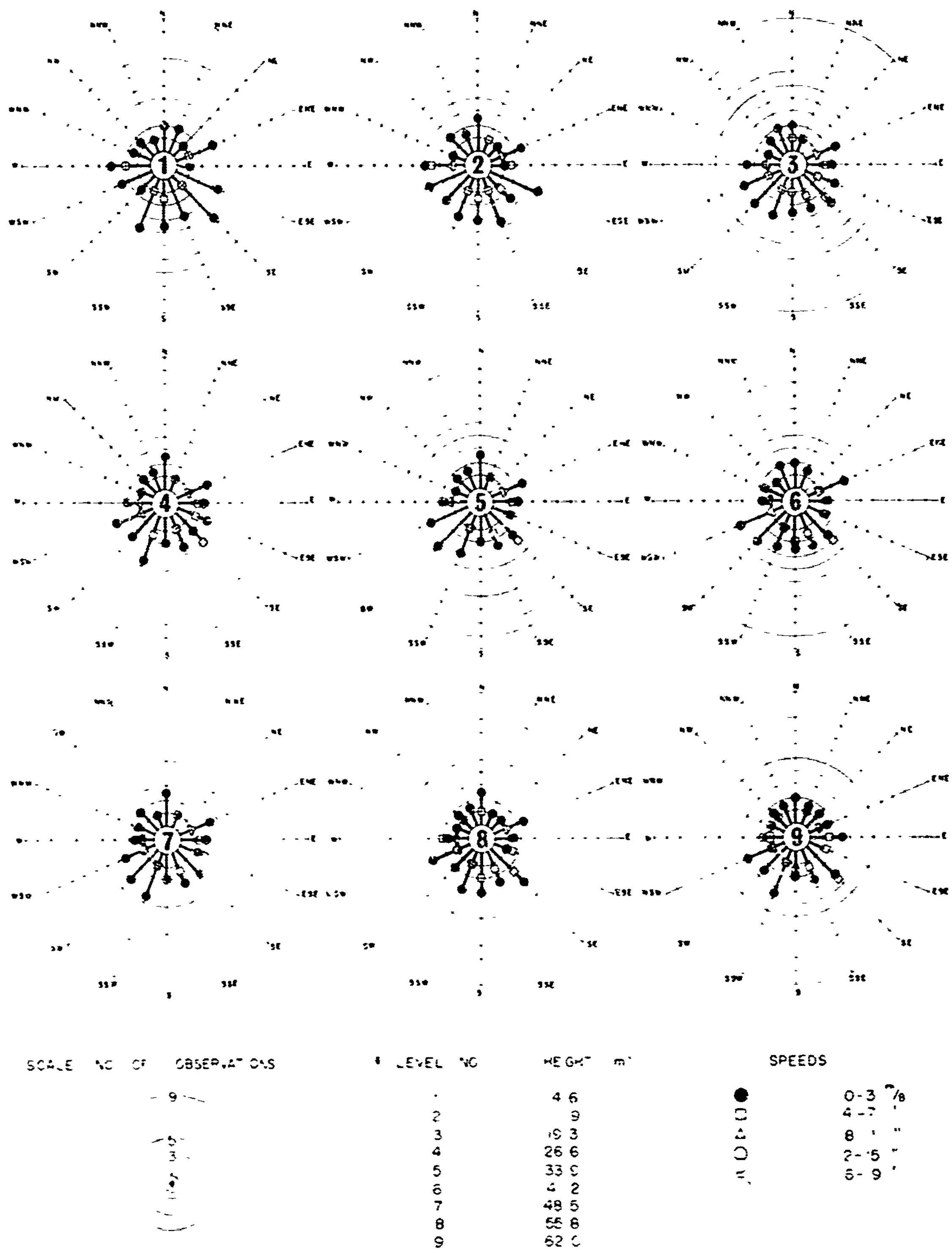


FIGURE 32: NIGHTTIME WIND ROSES FOR AUGUST

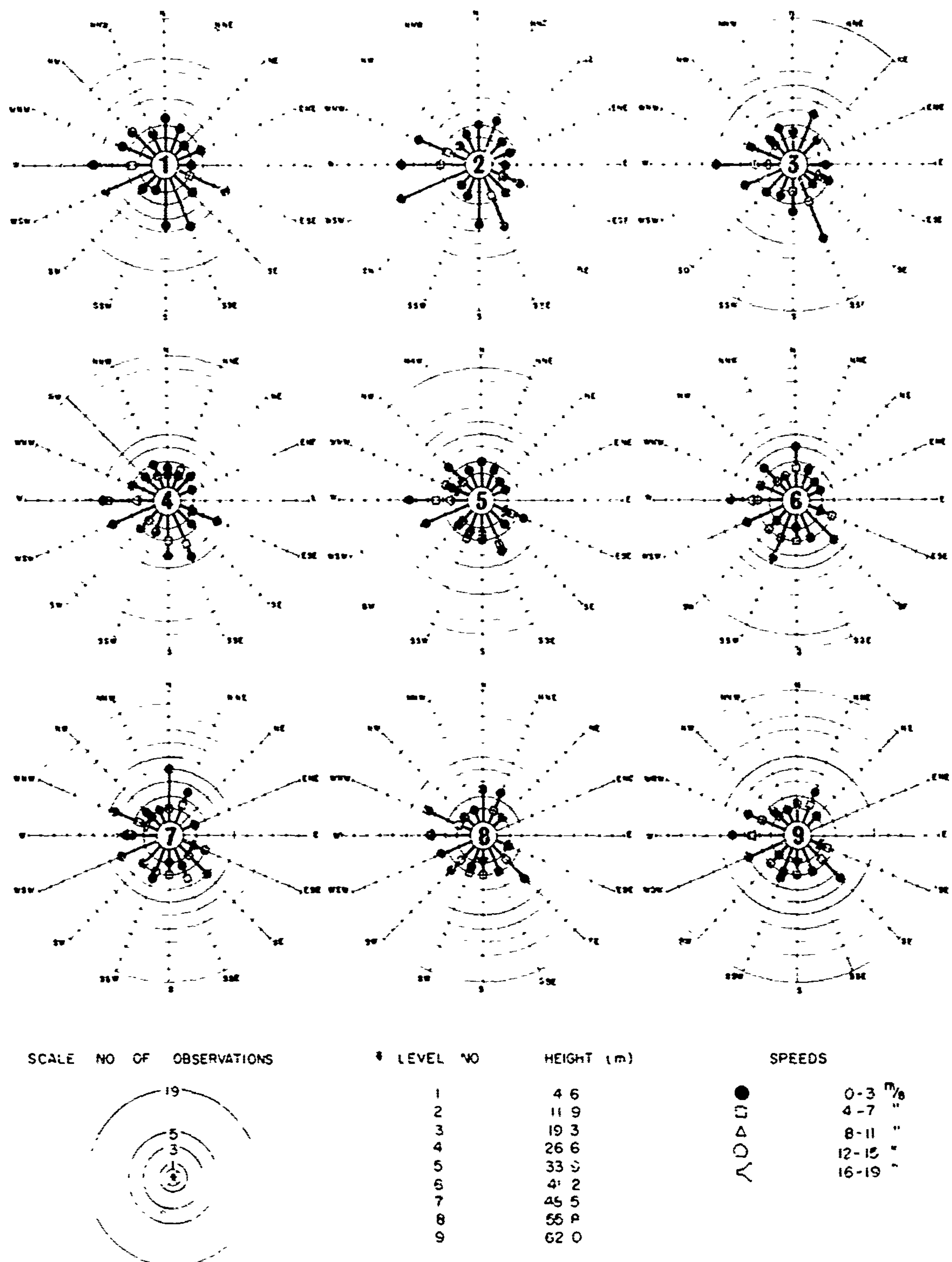


FIGURE 33: NIGHTTIME WIND ROSES FOR SEPTEMBER

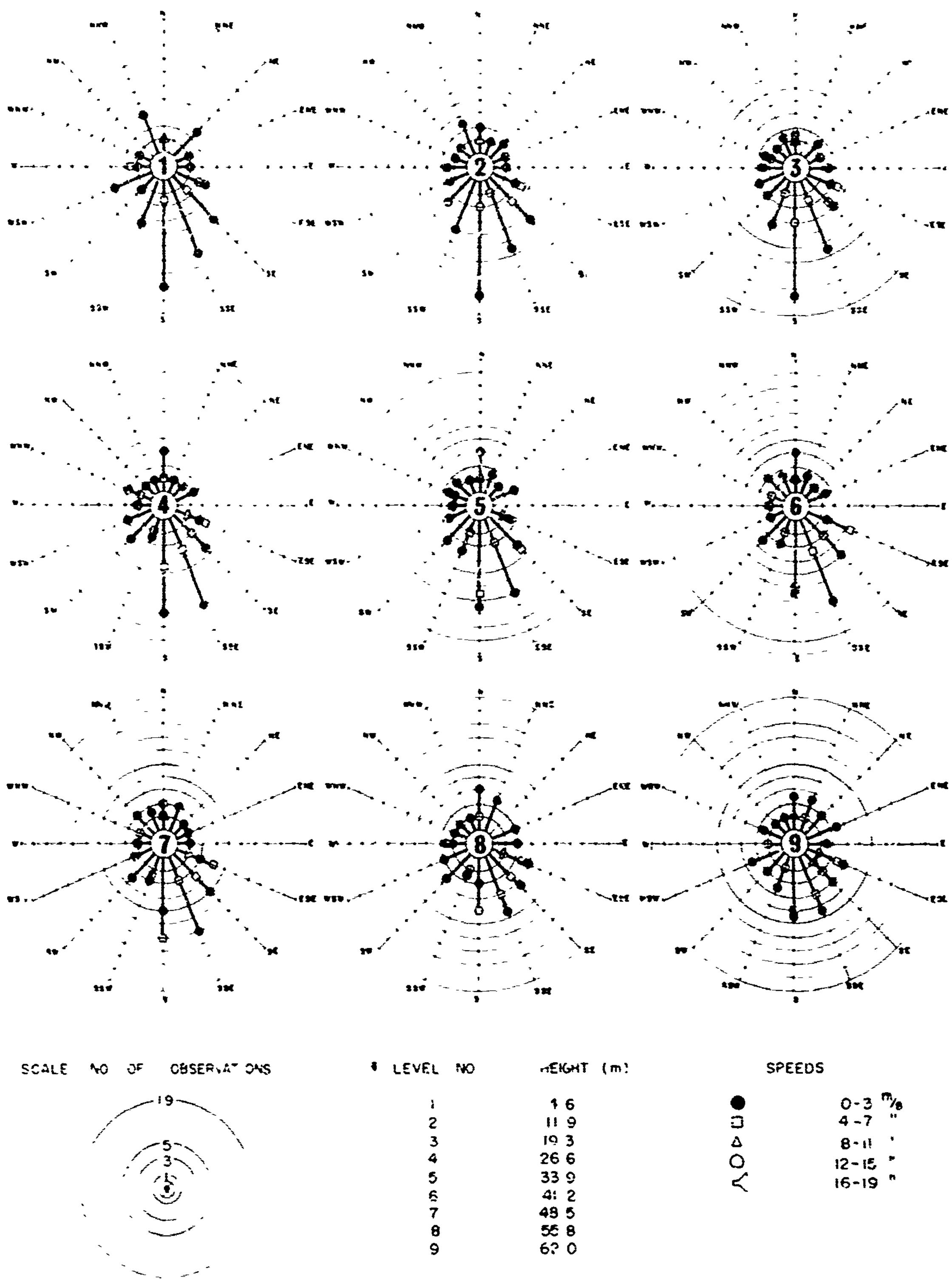


FIGURE 34: NIGHTTIME WIND ROSES FOR OCTOBER

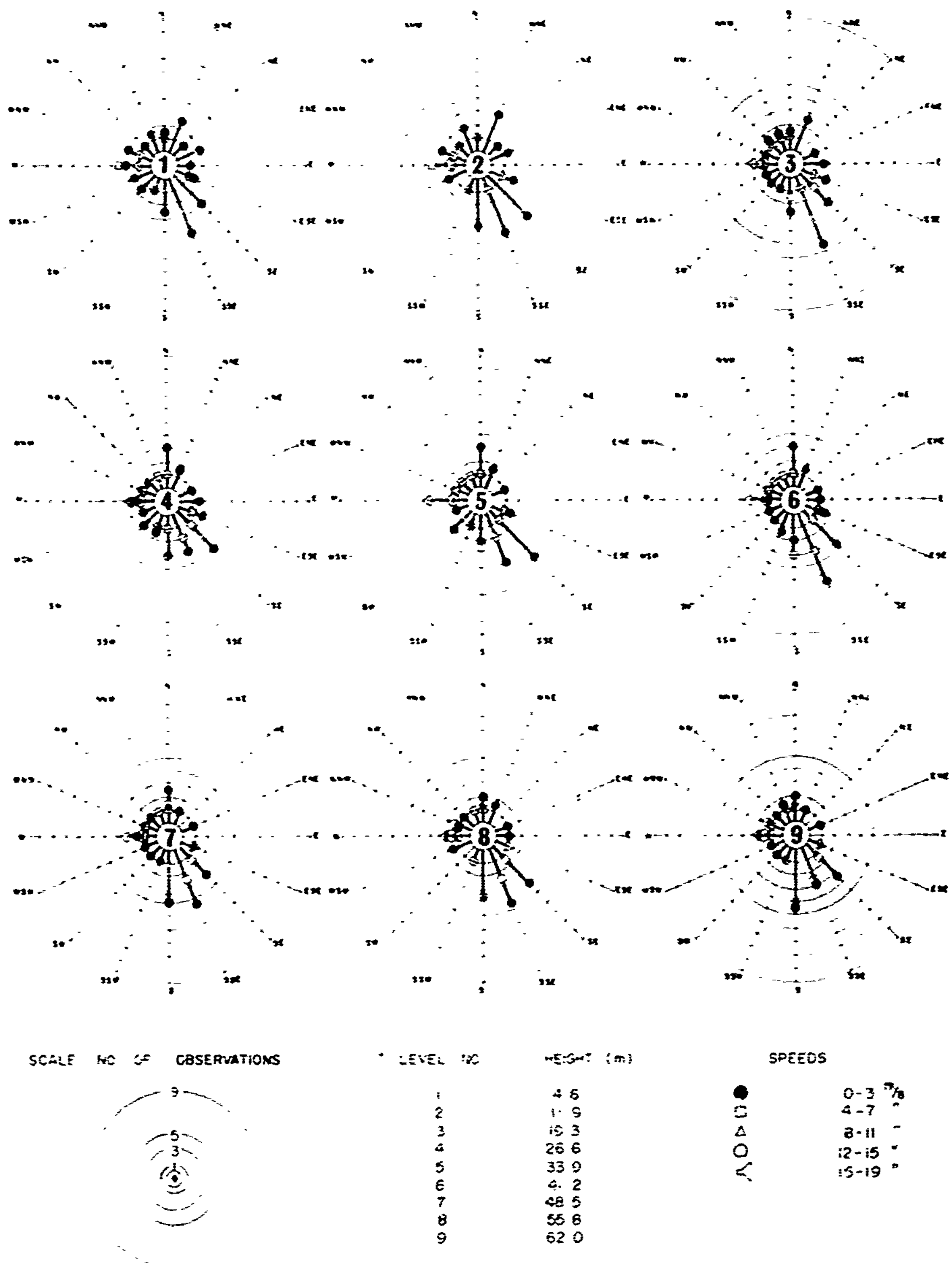


FIGURE 35: NIGHTTIME WIND ROSES FOR NOVEMBER

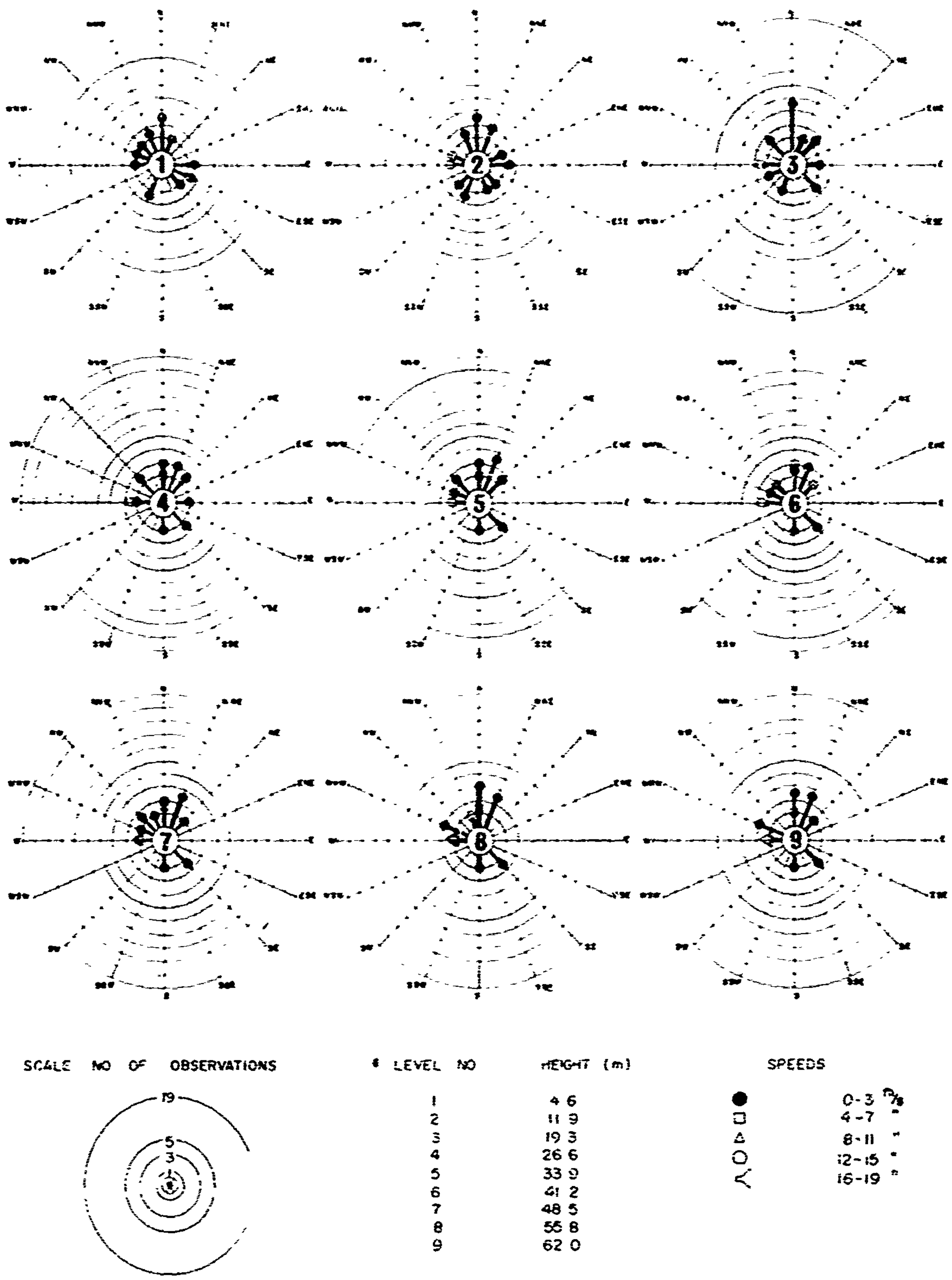


FIGURE 36: NIGHTTIME WIND ROSES FOR DECEMBER

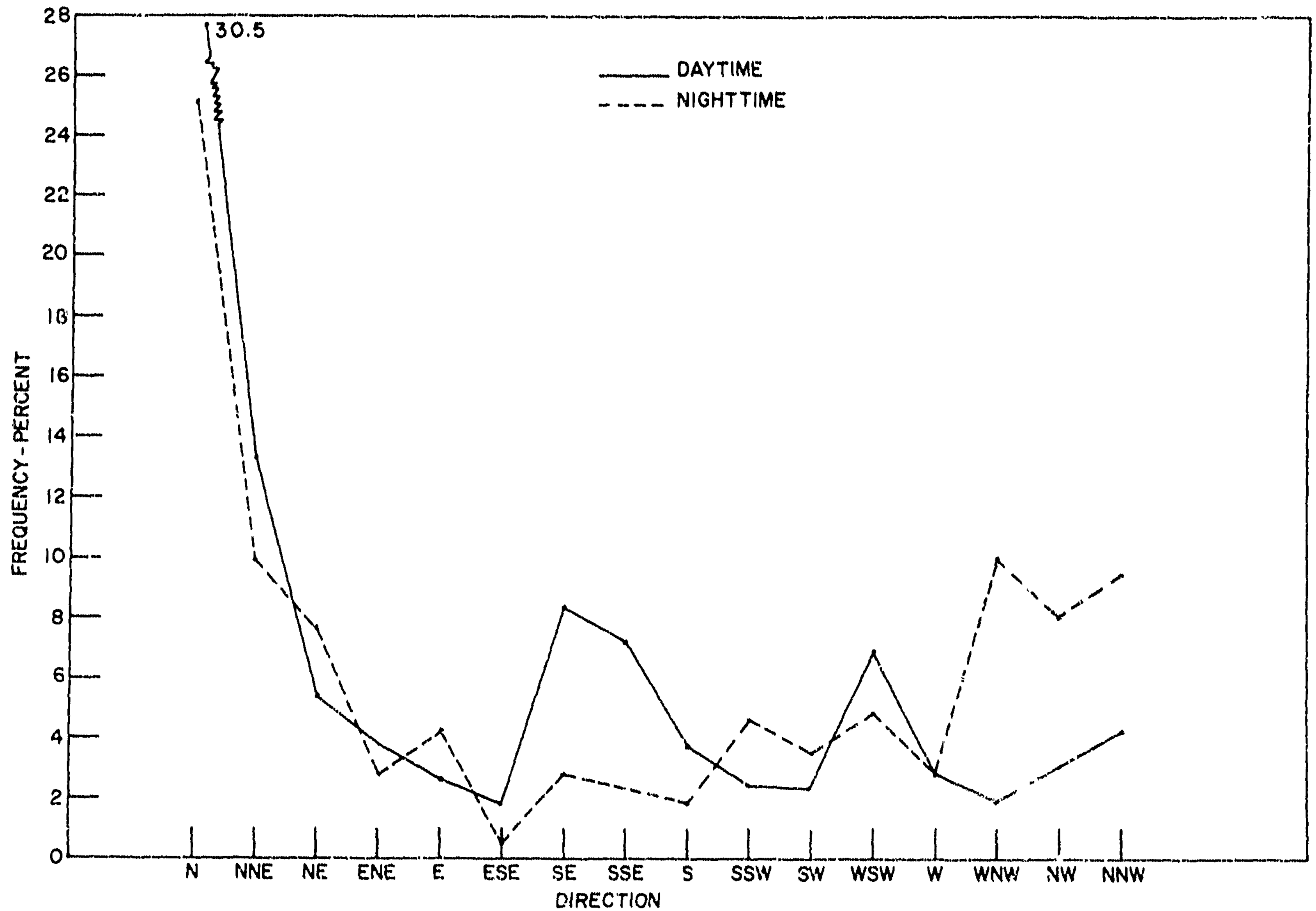


FIGURE 37 . PERCENT FREQUENCY OF OCCURRENCE OF WIND DIRECTION, JANUARY

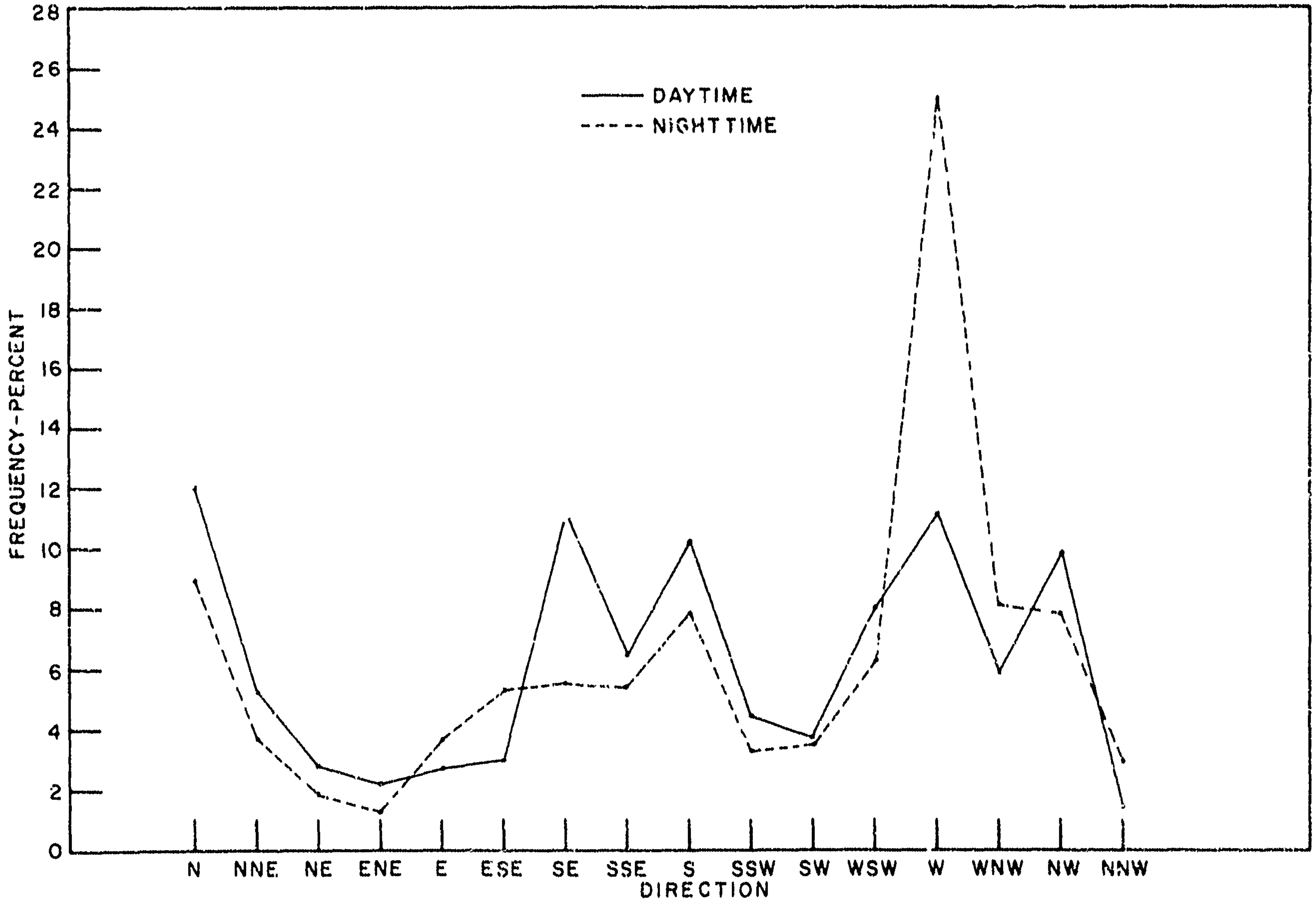


FIGURE 38: PERCENT FREQUENCY OF OCCURRENCE OF WIND DIRECTION, FEBRUARY

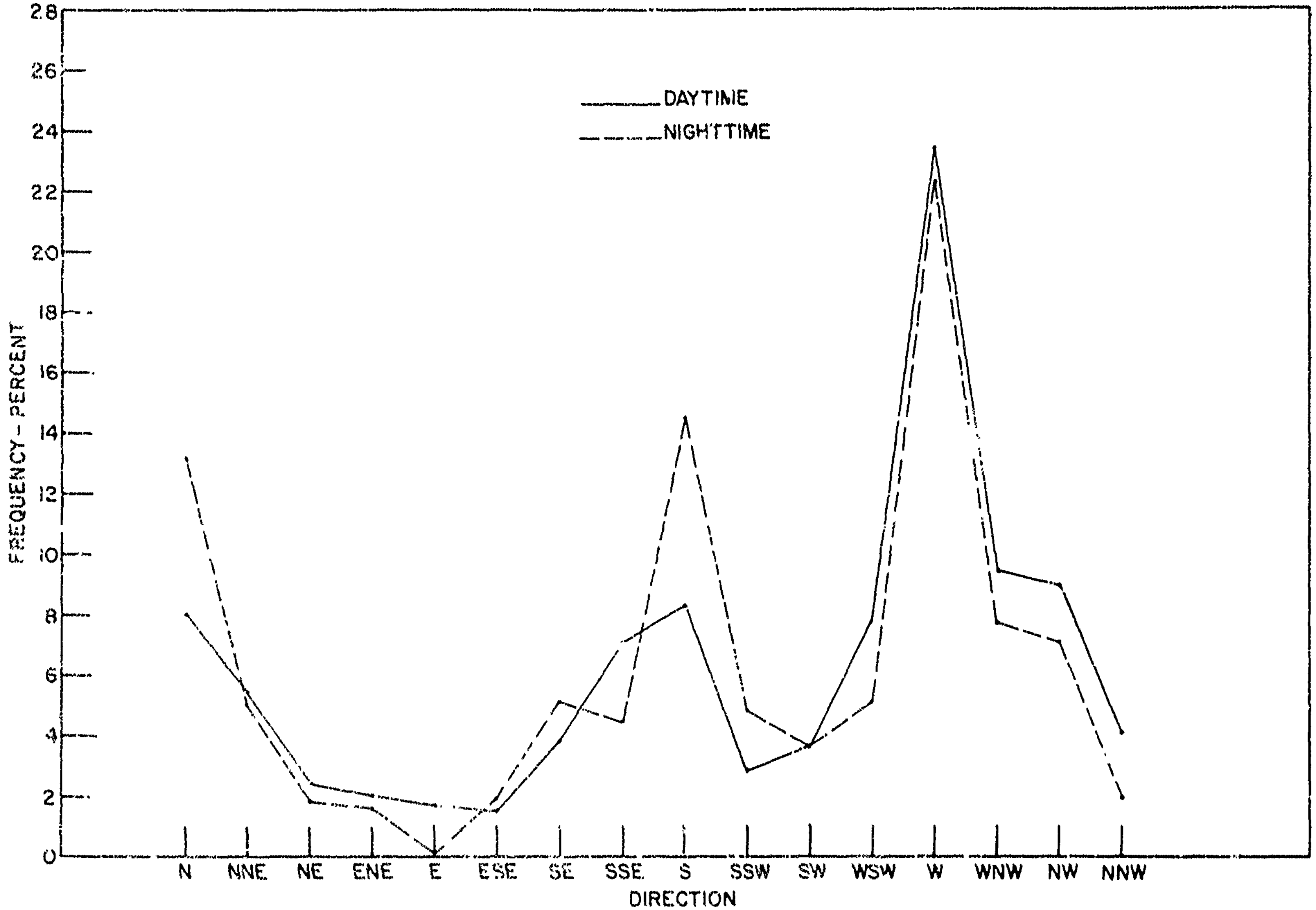


FIGURE 39 PERCENT FREQUENCY OF OCCURRENCE OF WIND DIRECTION, MARCH

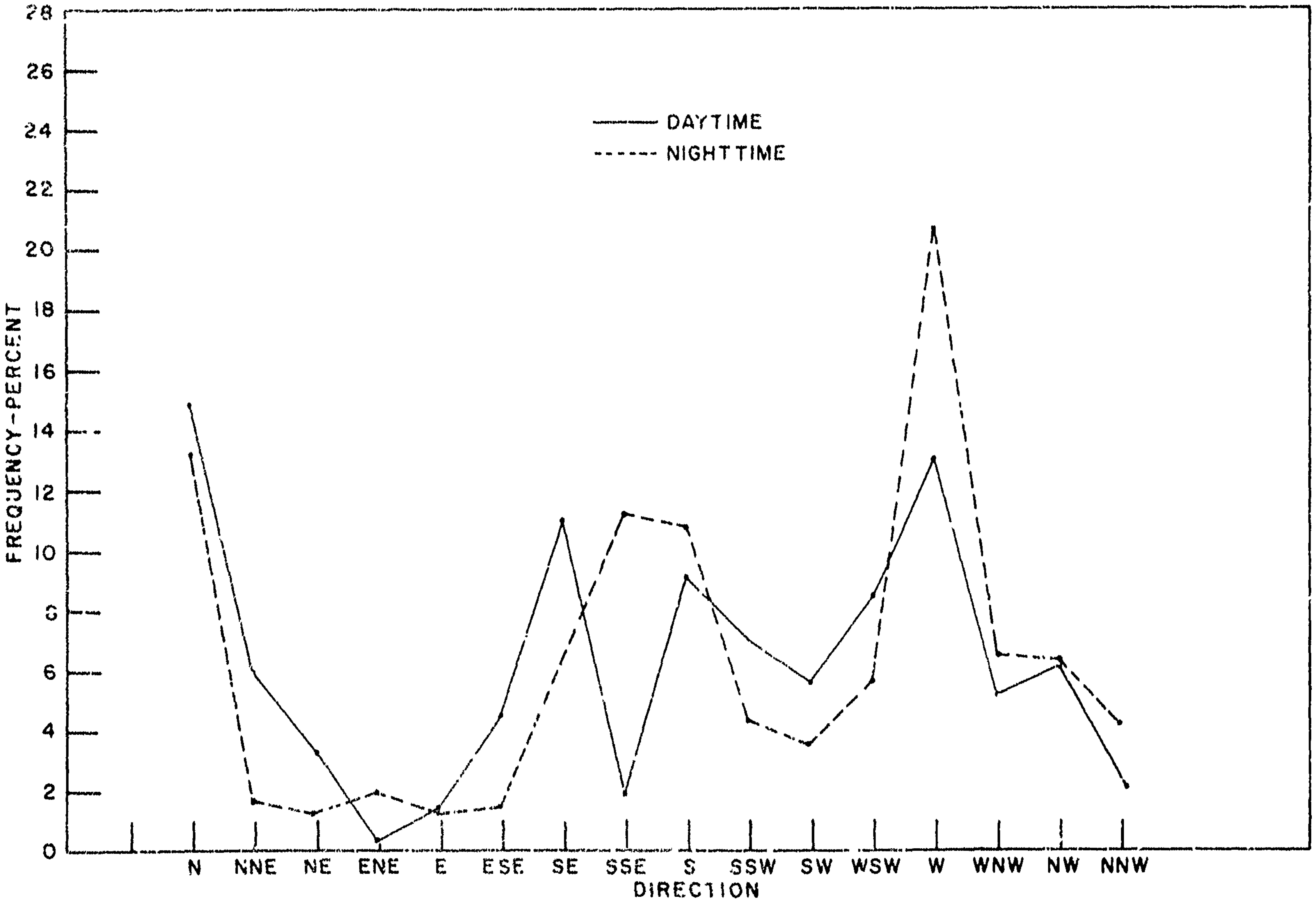


FIGURE 40: PERCENT FREQUENCY OF OCCURRENCE OF WIND DIRECTION, APRIL

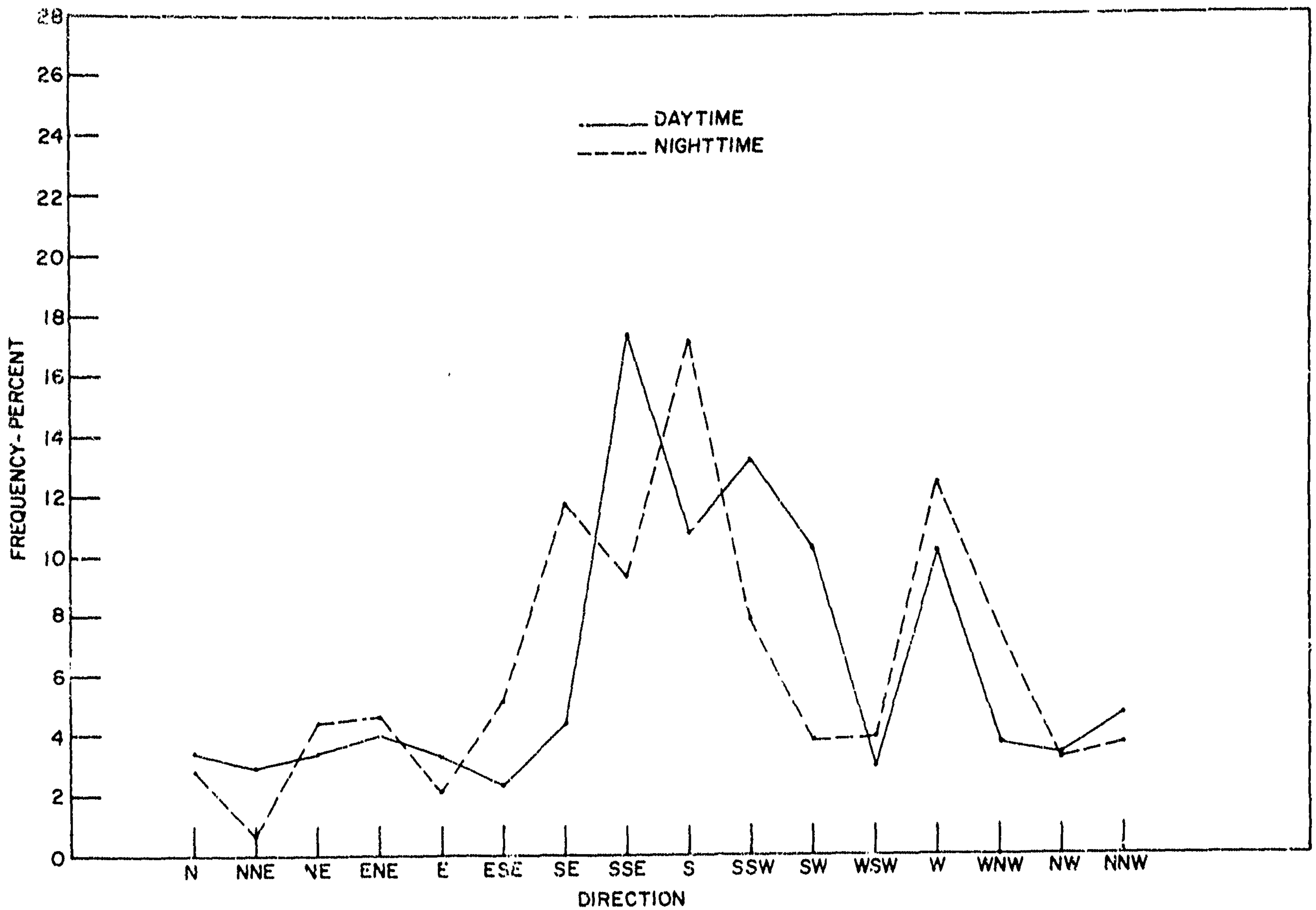


FIGURE 41: PERCENT FREQUENCY OF OCCURRENCE OF WIND DIRECTION, MAY

28

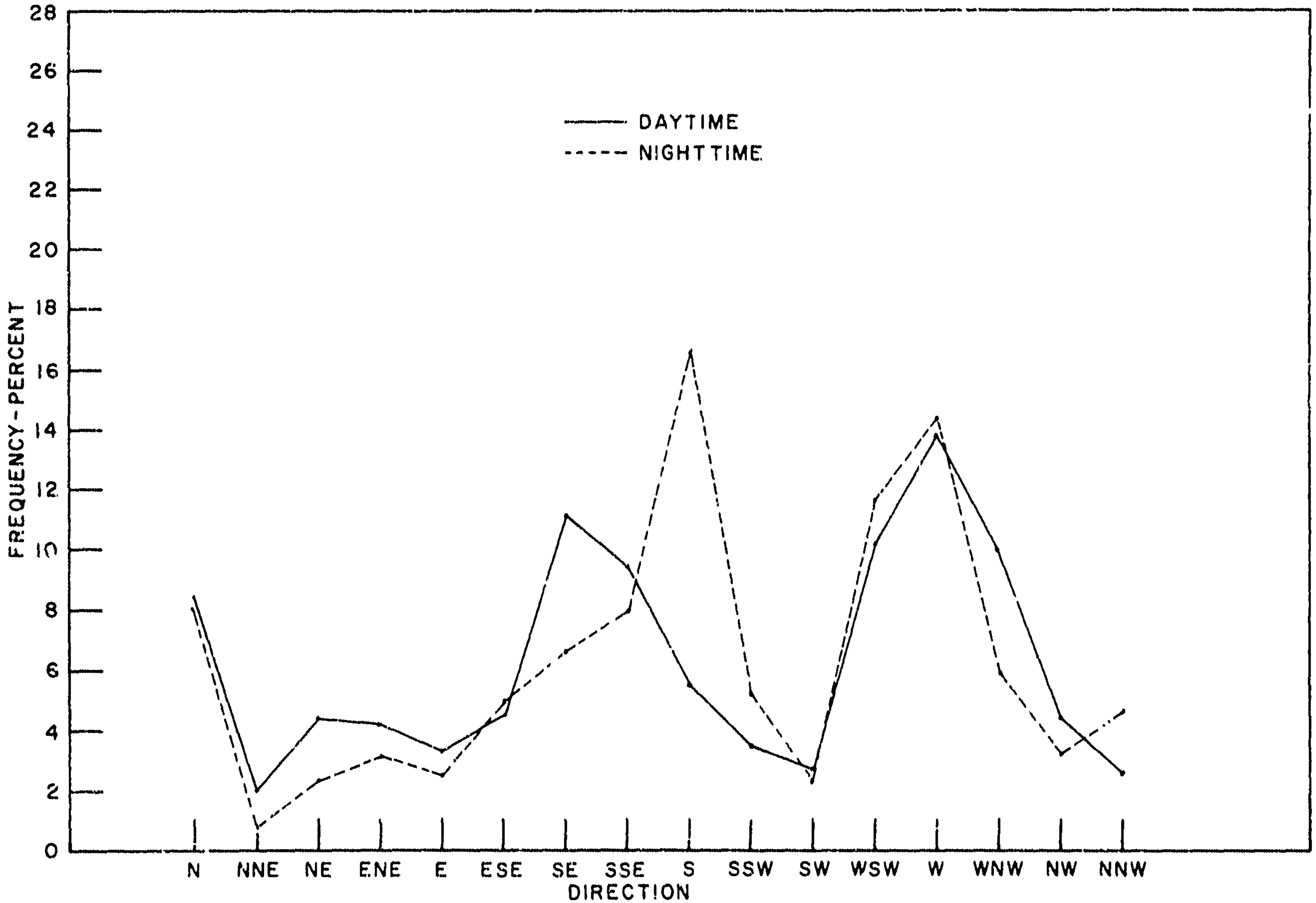


FIGURE 42: PERCENT FREQUENCY OF OCCURRENCE OF WIND DIRECTION, JUNE

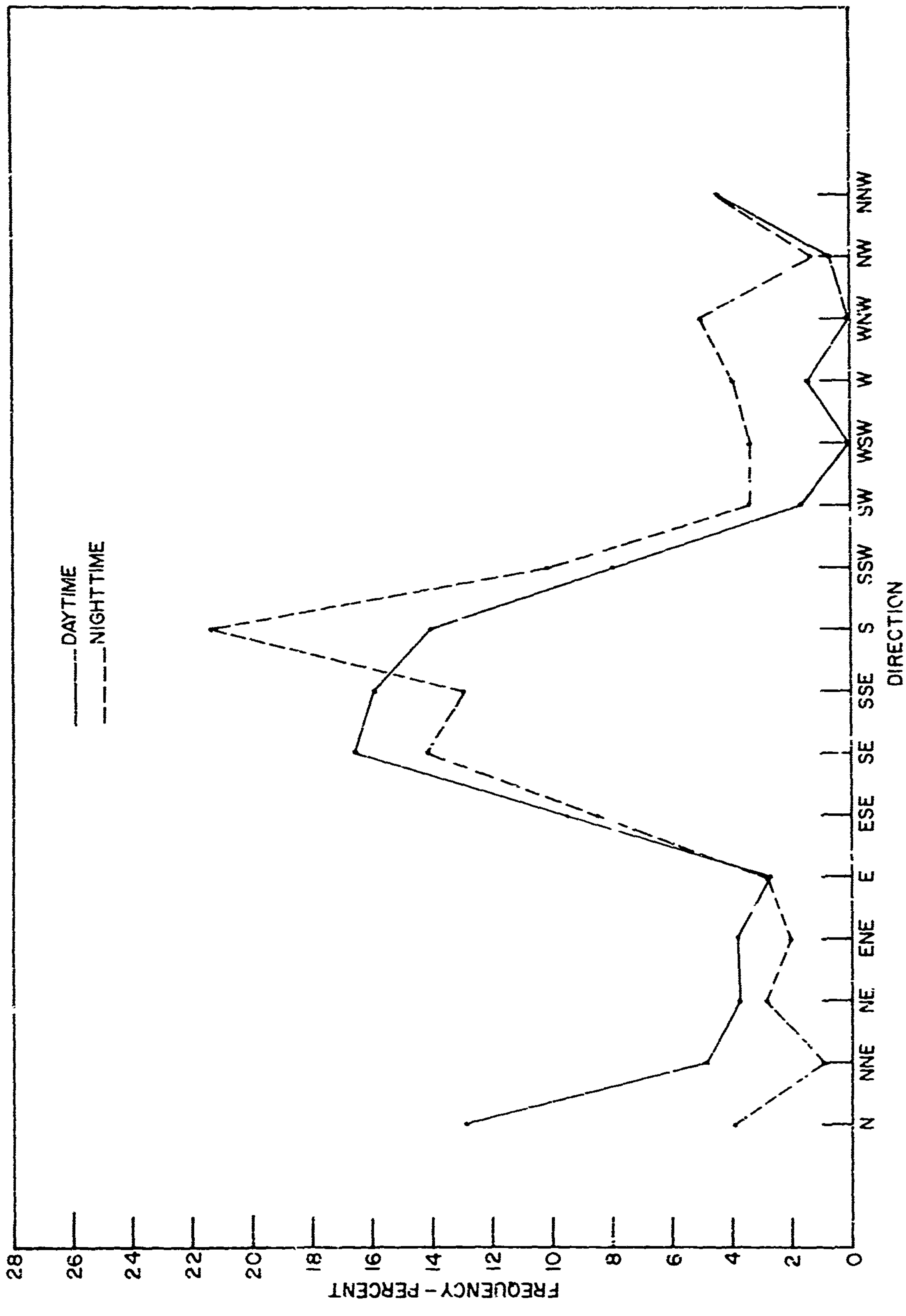


FIGURE 43: PERCENT FREQUENCY OF OCCURRENCE OF WIND DIRECTION, JULY

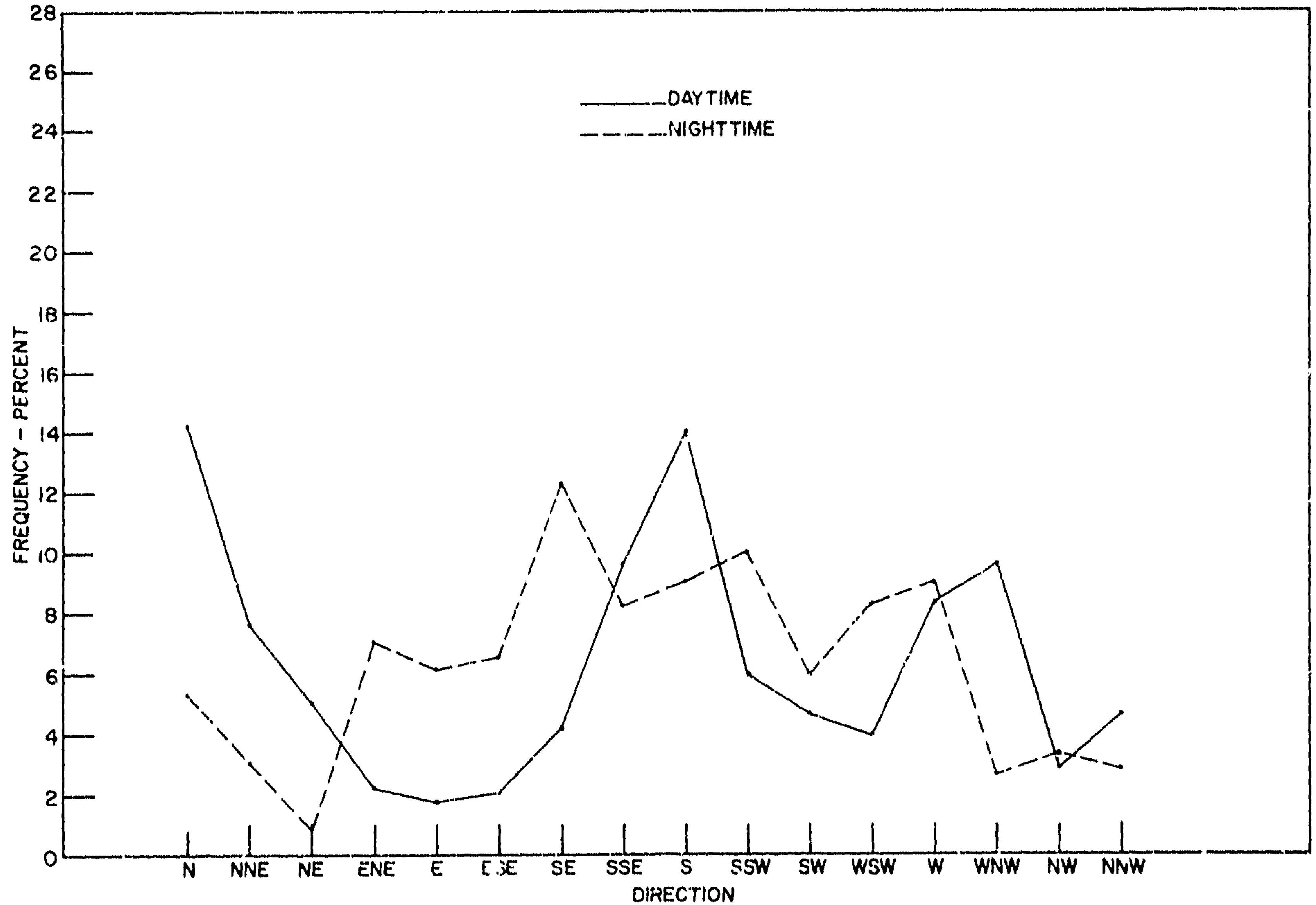


FIGURE 44: PERCENT FREQUENCY OF OCCURRENCE OF WIND DIRECTION, AUGUST

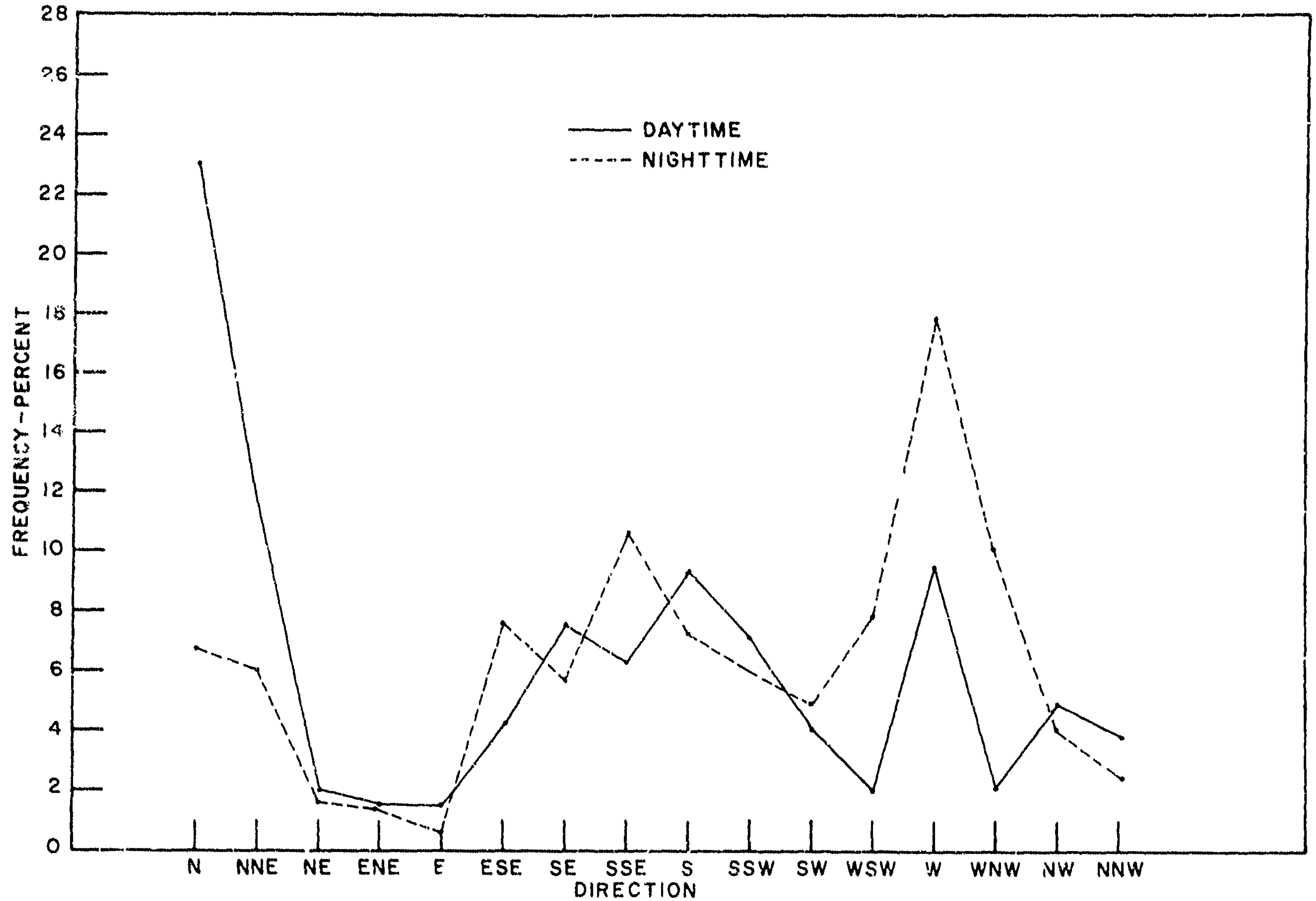


FIGURE 45: PERCENT FREQUENCY OF OCCURRENCE OF WIND DIRECTION, SEPTEMBER

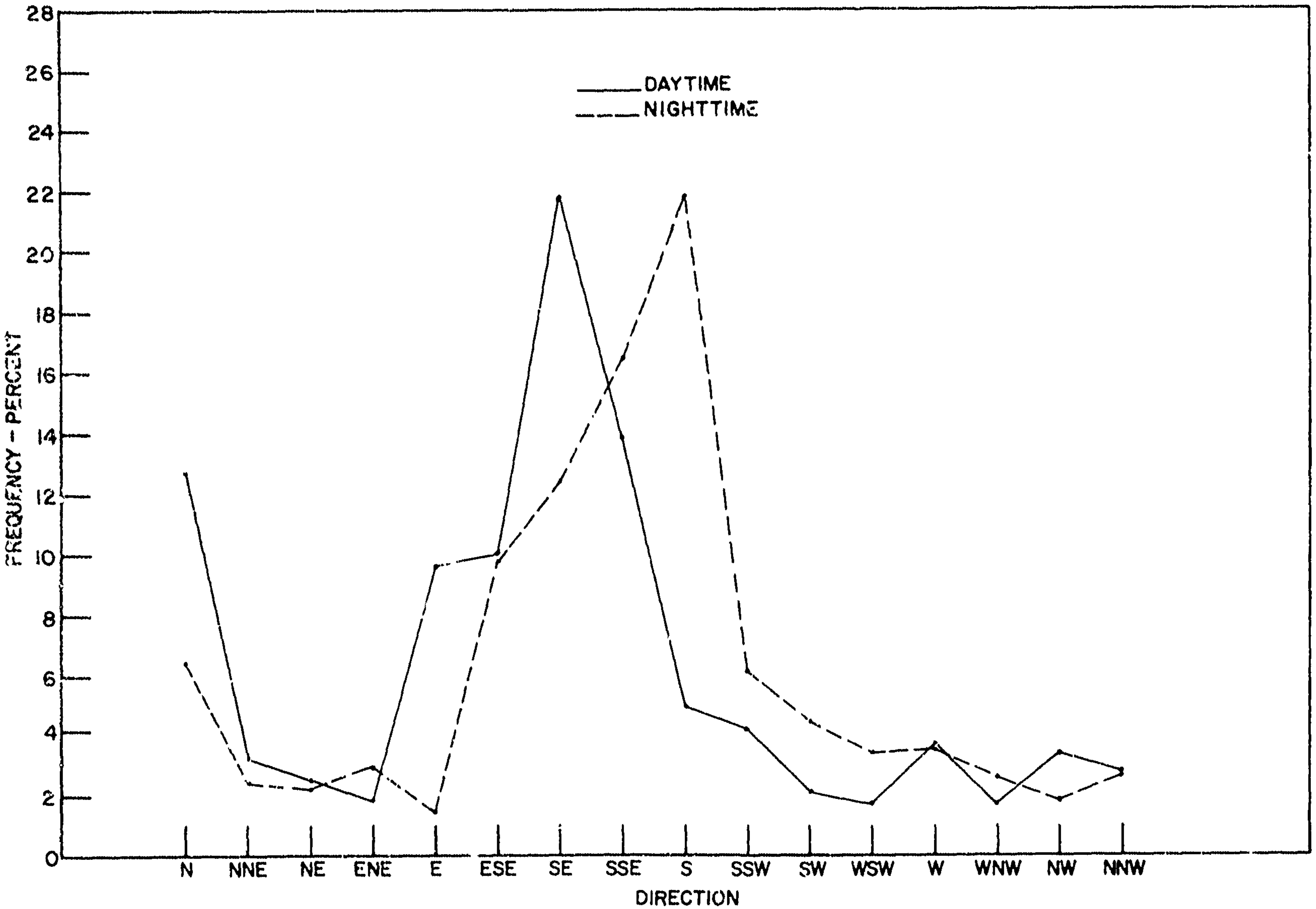


FIGURE 46: PERCENT FREQUENCY OF OCCURRENCE OF WIND DIRECTION, OCTOBER

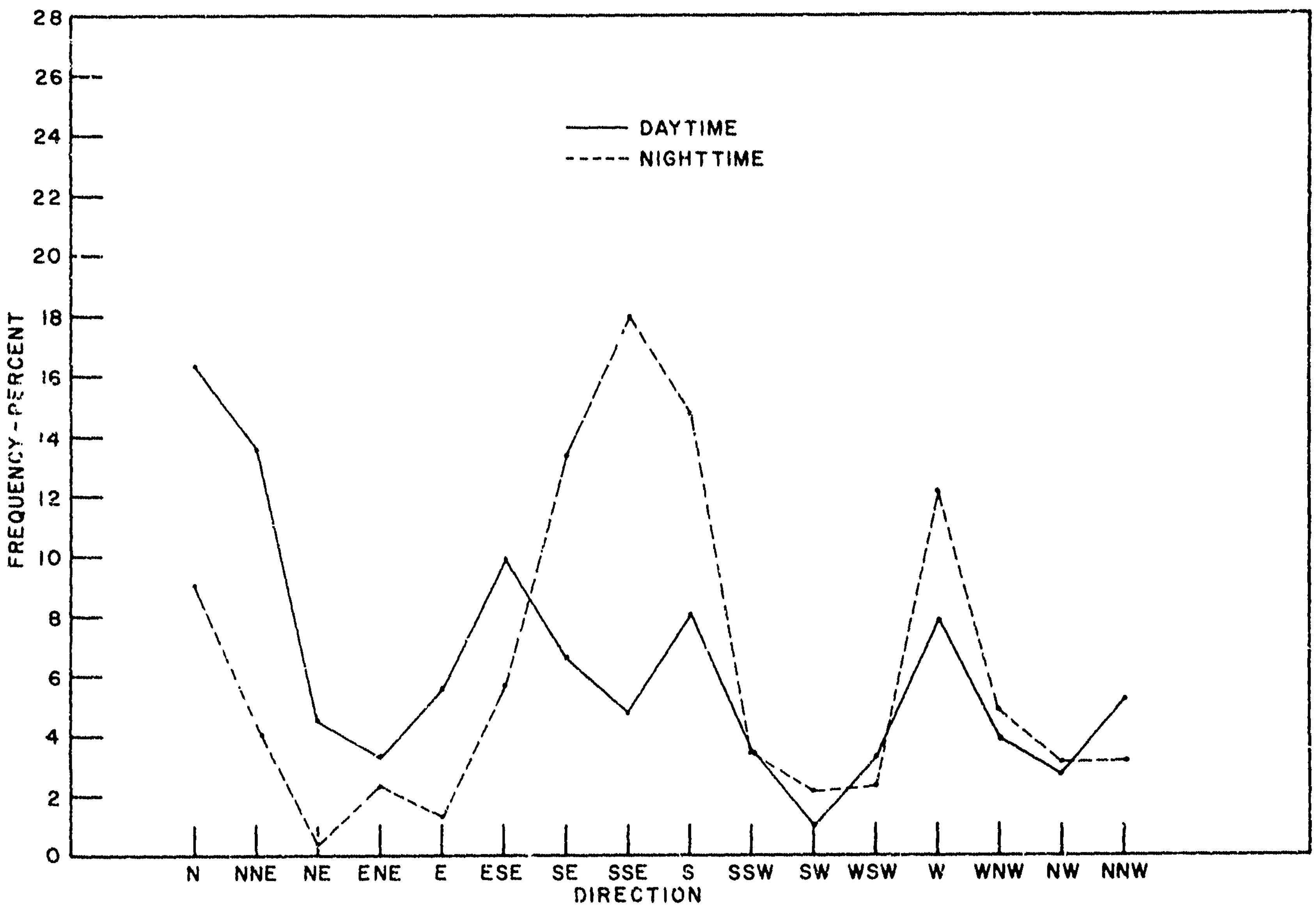


FIGURE 47: PERCENT FREQUENCY OF OCCURRENCE OF WIND DIRECTION, NOVEMBER

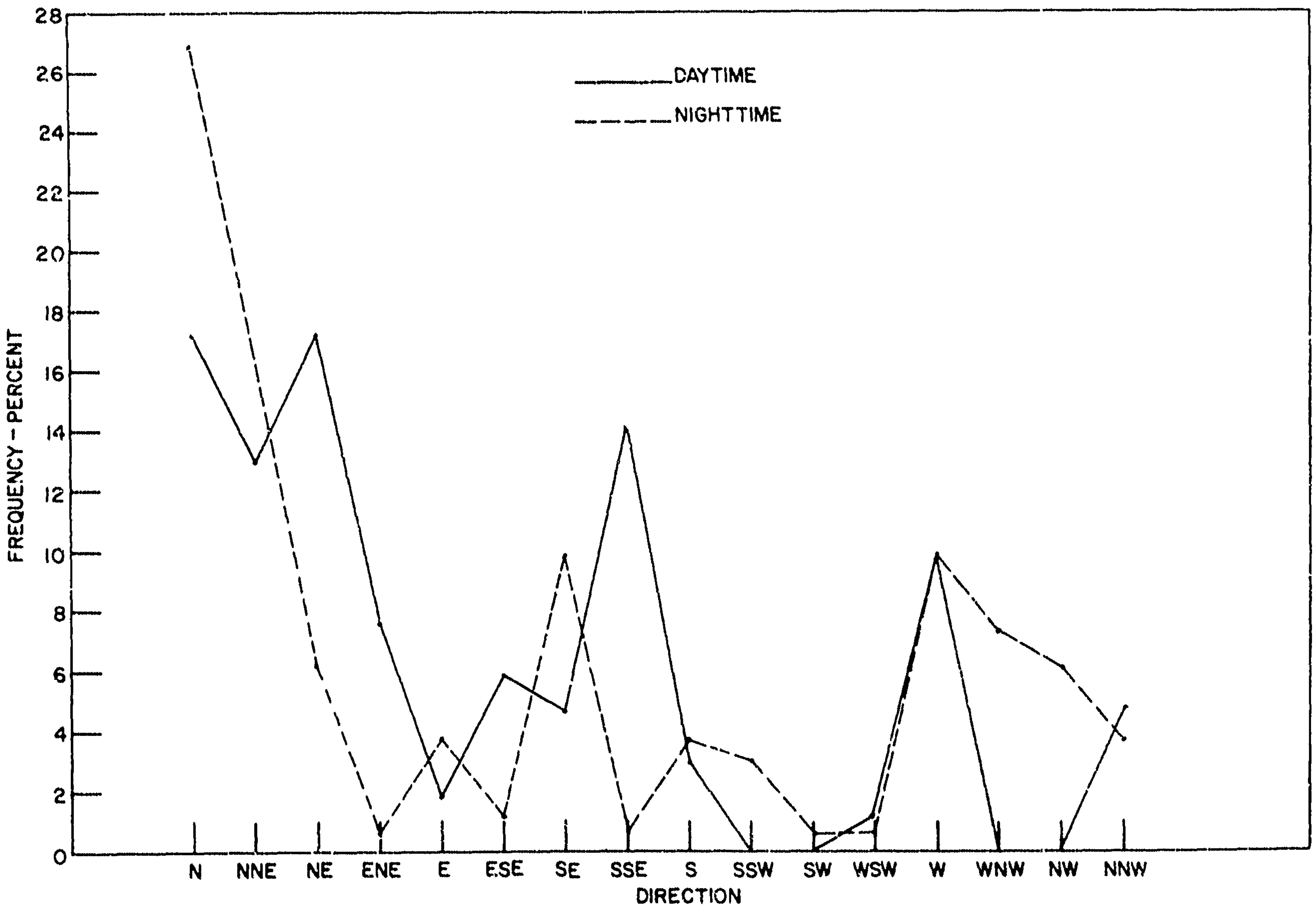


FIGURE 48: PERCENT FREQUENCY OF OCCURRENCE OF WIND DIRECTION, DECEMBER

REFERENCES

Carnes, P. S., 1961, Temperature Variations in the first 200 feet of the Atmosphere in an Arid Region, MM363, Missile Meteorology Division, U. S. Army Signal Missile Support Agency, White Sands Missile Range, New Mexico.

Hansen, F. V., 1963, Turbulence Characteristics of the first 62 meters of the Atmosphere, ERDA-100, U. S. Army Electronics Research and Development Activity, White Sands Missile Range, New Mexico.

Hansen, F. V. and V. D. Neill, 1964, Monthly Wind and Temperature Distributions in the first 62 meters of the Atmosphere, ERDA-113, U. S. Army Electronics Research and Development Activity, White Sands Missile Range, New Mexico.

Helvey, R., L. Traylor, and M. McClardie, 1959, Low-Level Wind Profile Prediction Techniques, Prog. Rpt. Nr. 1, U. S. Army Signal Missile Support Agency, White Sands Missile Range, New Mexico.

Helvey, R., 1960a, Low-Level Wind Profile Prediction Techniques, Prog. Rpt. Nr. 2, U. S. Army Signal Missile Support Agency, White Sands Missile Range, New Mexico.

Helvey, R., 1960b, Low-Level Wind Profile Prediction Techniques, Prog. Rpt. Nr. 3, U. S. Army Signal Missile Support Agency, White Sands Missile Range, New Mexico.

Swanson, R. N. and H. E. Cramer, 1965, A Study of Lateral and Longitudinal Intensities of Turbulence, J. Appl. Meteor. 4, 3, 409.

Swanson, R. N. and M. M. Hoidale, 1962, Low-Level Wind Profile Prediction Techniques, Prog. Rpt. Nr. 4, U. S. Army Signal Missile Support Agency, White Sands Missile Range, New Mexico.

Tourin, M. H. and M. M. Hoidale, 1962, Low-Level Turbulence Characteristics at White Sands Missile Range, MM-431, U. S. Army Signal Missile Support Agency, White Sands Missile Range, New Mexico.

ATMOSPHERIC SCIENCES RESEARCH PAPERS

1. Webb, W.L., "Development of Droplet Size Distributions in the Atmosphere," June 1954.

2. Hansen, F. V., and H. Rachele, "Wind Structure Analysis and Forecasting Methods for Rockets," June 1954.

3. Webb, W. L., "Net Electrification of Water Droplets at the Earth's Surface," *J. Meteorol.*, December 1954.

4. Mitchell, R., "The Determination of Non-Ballistic Projectile Trajectories," March 1955.

5. Webb, W. L., and A. McPike, "Sound Ranging Technique for Determining the Trajectory of Supersonic Missiles," #1, March 1955.

6. Mitchell, R., and W. L. Webb, "Electromagnetic Radiation through the Atmosphere," #1, April 1955.

7. Webb, W. L., A. McPike, and H. Thompson, "Sound Ranging Technique for Determining the Trajectory of Supersonic Missiles," #2, July 1955.

8. Barichivich, A., "Meteorological Effects on the Refractive Index and Curvature of Microwaves in the Atmosphere," August 1955.

9. Webb, W. L., A. McPike and H. Thompson, "Sound Ranging Technique for Determining the Trajectory of Supersonic Missiles," #3, September 1955.

10. Mitchell, R., "Notes on the Theory of Longitudinal Wave Motion in the Atmosphere," February 1956.

11. Webb, W. L., "Particulate Counts in Natural Clouds," *J. Meteorol.*, April 1956.

12. Webb, W. L., "Wind Effect on the Aerobee," #1, May 1956.

13. Rachele, H., and L. Anderson, "Wind Effect on the Aerobee," #2, August 1956.

14. Beyers, N., "Electromagnetic Radiation through the Atmosphere," #2, January 1957.

15. Hansen, F. V., "Wind Effect on the Aerobee," #3, January 1957.

16. Kershner, J., and H. Bear, "Wind Effect on the Aerobee," #4, January 1957.

17. Hoidale, G., "Electromagnetic Radiation through the Atmosphere," #3, February 1957.

18. Querfeld, C. W., "The Index of Refraction of the Atmosphere for 2.2 Micron Radiation," March 1957.

19. White, Lloyd, "Wind Effect on the Aerobee," #5, March 1957.

20. Kershner, J. G., "Development of a Method for Forecasting Component Ballistic Wind," August 1957.

21. Layton, Ivan, "Atmospheric Particle Size Distribution," December 1957.

22. Rachele, Henry and W. H. Hatch, "Wind Effect on the Aerobee," #6, February 1958.

23. Beyers, N. J., "Electromagnetic Radiation through the Atmosphere," #4, March 1958.

24. Prosser, Shirley J., "Electromagnetic Radiation through the Atmosphere," #5, April 1958.

25. Armendariz, M., and P. H. Taft, "Double Theodolite Ballistic Wind Computations," June 1958.

26. Jenkins, K. R. and W. L. Webb, "Rocket Wind Measurements," June 1958.

27. Jenkins, K. R., "Measurement of High Altitude Winds with Loki," July 1958.

28. Hoidale, G., "Electromagnetic Propagation through the Atmosphere," #6, February 1959.

29. McLardie, M., R. Helvey, and L. Traylor, "Low-Level Wind Profile Prediction Techniques," #1, June 1959.

30. Lamberth, Roy, "Gustiness at White Sands Missile Range," #1, May 1959.

31. Beyers, N. J., B. Hinds, and G. Hoidale, "Electromagnetic Propagation through the Atmosphere," #7, June 1959.

32. Beyers, N. J., "Radar Refraction at Low Elevation Angles (U)," Proceedings of the Army Science Conference, June 1959.

33. White, L., O. W. Thiele and P. H. Taft, "Summary of Ballistic and Meteorological Support During IGY Operations at Fort Churchill, Canada," August 1959.

34. Hainline, D. A., "Drag Cord-Aerovane Equation Analysis for Computer Application," August 1959.

35. Hoidale, G. B., "Slope-Valley Wind at WSMR," October 1959.

36. Webb, W. L., and K. R. Jenkins, "High Altitude Wind Measurements," *J. Meteorol.*, 16, 5, October 1959.

37. White, Lloyd, "Wind Effect on the Aerobee," #9, October 1959.

38. Webb, W. L., J. W. Coffman, and G. Q. Clark, "A High Altitude Acoustic Sensing System," December 1959.

39. Webb, W. L., and K. R. Jenkins, "Application of Meteorological Rocket Systems," J. Geophys. Res., 64, 11, November 1959.

40. Duncan, Louis, "Wind Effect on the Aerobee," #10, February 1960.

41. Helvey, R. A., "Low-Level Wind Profile Prediction Techniques," #2, February 1960.

42. Webb, W. L., and K. R. Jenkins, "Rocket Sounding of High-Altitude Parameters," *Proc. GM Rel. Symp.*, Dept. of Defense, February 1960.

43. Armendariz, M., and H. H. Monahan, "A Comparison Between the Double Theodolite and Single-Theodolite Wind Measuring Systems," April 1960.

44. Jenkins, K. R., and P. H. Taft, "Weather Elements in the Tularosa Basin," July 1960.

45. Beyers, N. J., "Preliminary Radar Performance Data on Passive Rocket-Borne Wind Sensors," IRE TRANS, MIL ELECT, MIL-4, 2-3, April-July 1960.

46. Webb, W. L., and K. R. Jenkins, "Speed of Sound in the Stratosphere," June 1960.

47. Webb, W. L., K. R. Jenkins, and G. Q. Clark, "Rocket Sounding of High Atmosphere Meteorological Parameters," *IRE Trans. Mil. Elect.*, MIL-4, 2-3, April-July 1960.

48. Helvey, R. A., "Low-Level Wind Profile Prediction Techniques," #3, September 1960.

49. Beyers, N. J., and O. W. Thiele, "Meteorological Wind Sensors," August 1960.

50. Armijo, Larry, "Determination of Trajectories Using Range Data from Three Noncolinear Radar Stations," September 1960.

51. Carnes, Patsy Sue, "Temperature Variations in the First 200 Feet of the Atmosphere in an Arid Region," July 1961.

52. Springer, H. S., and R. O. Olsen, "Launch Noise Distribution of Nike-Zeus Missiles," July 1961.

53. Thiele, O. W., "Density and Pressure Profiles Derived from Meteorological Rocket Measurements," September 1961.

54. Diamond, M. and A. B. Gray, "Accuracy of Missile Sound Ranging," November 1961.

55. Lamberth, R. L. and D. R. Veith, "Variability of Surface Wind in Short Distances," #1, October 1961.

56. Swanson, R. N., "Low-Level Wind Measurements for Ballistic Missile Application," January 1962.

57. Lamberth, R. L. and J. H. Grace, "Gustiness at White Sands Missile Range," #2, January 1962.

58. Swanson, R. N. and M. M. Hoidale, "Low-Level Wind Profile Prediction Techniques," #4, January 1962.

59. Rachele, Henry, "Surface Wind Model for Unguided Rockets Using Spectrum and Cross Spectrum Techniques," January 1962.

60. Rachele, Henry, "Sound Propagation through a Windy Atmosphere," #2, February 1962.

61. Webb, W. L., and K. R. Jenkins, "Sonic Structure of the Mesosphere," *J. Acous. Soc. Amer.*, 34, 2, February 1962.

62. Tourin, M. H. and M. M. Hoidale, "Low-Level Turbulence Characteristics at White Sands Missile Range," April 1962.

63. Miers, Bruce T., "Mesospheric Wind Reversal over White Sands Missile Range," March 1962.

64. Fisher, E., R. Lee and H. Rachele, "Meteorological Effects on an Acoustic Wave within a Sound Ranging Array," May 1962.

65. Walter, E. L., "Six Variable Ballistic Model for a Rocket," June 1962.

66. Webb, W. L., "Detailed Acoustic Structure Above the Tropopause," *J. Applied Meteorol.*, 1, 2, June 1962.

67. Jenkins, K. R., "Empirical Comparisons of Meteorological Rocket Wind Sensors," *J. Appl. Meteor.*, June 1962.

68. Lamberth, Roy, "Wind Variability Estimates as a Function of Sampling Interval," July 1962.

69. Rachele, Henry, "Surface Wind Sampling Periods for Unguided Rocket Impact Prediction," July 1962.

70. Traylor, Larry, "Coriolis Effects on the Aerobee-Hi Sounding Rocket," August 1962.

71. McCoy, J., and G. Q. Clark, "Meteorological Rocket Thermometry," August 1962.

72. Rachele, Henry, "Real-Time Prelaunch Impact Prediction System," August 1962.

73. Beyers, N. J., O. W. Thiele, and N. K. Wagner, "Performance Characteristics of Meteorlogical Rocket Wind and Temperature Sensors," October 1962.

74. Coffman, J., and R. Price, "Some Errors Associated with Acoustical Wind Measurements through a Layer," October 1962.

75. Armendariz, M., E. Fisher, and J. Serna, "Wind Shear in the Jet Stream at WSMR," November 1962.

76. Armendariz, M., F. Hansen, and S. Carnes, "Wind Variability and its Effect on Rocket Impact Prediction," January 1963.

77. Querfeld, C., and Wayne Yunker, "Pure Rotational Spectrum of Water Vapor, I: Table of Line Parameters," February 1963.

78. Webb, W. L., "Acoustic Component of Turbulence," *J. Applied Meteorol.*, 2, 2, April 1963.

79. Beyers, N. and L. Engberg, "Seasonal Variability in the Upper Atmosphere," May 1963.

80. Williamson, L. E., "Atmospheric Acoustic Structure of the Sub-polar Fall," May 1963.

81. Lamberth, Roy and D. Veith, "Upper Wind Correlations in Southwestern United States," June 1963.

82. Sandlin, E., "An analysis of Wind Shear Differences as Measured by AN/FPS-16 Radar and AN/GMD-1B Rawinsonde," August 1963.

83. Diamond, M. and R. P. Lee, "Statistical Data on Atmospheric Design Properties Above 30 km," August 1963.

84. Thiele, O. W., "Mesospheric Density Variability Based on Recent Meteorological Rocket Measurements," *J. Applied Meteorol.*, 2, 5, October 1963.

85. Diamond, M., and O. Essenwanger, "Statistical Data on Atmospheric Design Properties to 30 km," *Astro. Aero. Engr.*, December 1963.

86. Hansen, F. V., "Turbulence Characteristics of the First 62 Meters of the Atmosphere," December 1963.

87. Morris, J. E., and B. T. Miers, "Circulation Disturbances Between 25 and 70 kilometers Associated with the Sudden Warming of 1963," *J. of Geophys. Res.*, January 1964.

88. Thiele, O. W., "Some Observed Short Term and Diurnal Variations of Stratospheric Density Above 30 km," January 1964.

89. Sandlin, R. E., Jr. and E. Armijo, "An Analysis of AN/FPS-16 Radar and AN/GMD-1B Rawinsonde Data Differences," January 1964.

90. Miers, B. T., and N. J. Beyers, "Rocketsonde Wind and Temperature Measurements Between 30 and 70 km for Selected Stations," *J. Applied Meteorol.*, February 1964.

91. Webb, W. L., "The Dynamic Stratosphere," *Astronautics and Aerospace Engineering*, March 1964.

92. Low, R. D. H., "Acoustic Measurements of Wind through a Layer," March 1964.

93. Diamond. M., "Cross Wind Effect on Sound Propagation," *J. Applied Meteorol.*, April 1964.

94. Lee, R. P., "Acoustic Ray Tracing," April 1964.

95. Reynolds, R. D., "Investigation of the Effect of Lapse Rate on Balloon Ascent Rate," May 1964.

96. Webb, W. L., "Scale of Stratospheric Detail Structure," *Space Research V*, May 1964.

97. Barber, T. L., "Proposed X-Ray-Infrared Method for Identification of Atmospheric Mineral Dust," June 1964.

98. Thiele, O. W., "Ballistic Procedures for Unguided Rocket Studies of Nuclear Environments (U)," Proceedings of the Army Science Conference, June 1964.

99. Horn, J. D., and E. J. Trawle, "Orographic Effects on Wind Variability," July 1964.

100. Hoidale, G., C. Querfeld, T. Hall, and R. Mireles, "Spectral Transmissivity of the Earth's Atmosphere in the 250 to 500 Wave Number Interval," #1, September 1964.

101. Duncan, L. D., R. Ensey, and B. Engebos, "Athena Launch Angle Determination," September 1964.

102. Thiele, O. W., "Feasibility Experiment for Measuring Atmospheric Density Through the Altitude Range of 60 to 100 KM Over White Sands Missile Range," October 1964.

103. Duncan, L. D., and R. Ensey, "Six-Degree-of-Freedom Digital Simulation Model for Unguided, Fin-Stabilized Rockets," November 1964.

104. Hoidale, G., C. Querfeld, T. Hall, and R. Mireles, "Spectral Transmissivity of the Earth's Atmosphere in the 250 to 500 Wave Number Interval," #2, November 1964.

105. Webb, W. L., "Stratospheric Solar Response," *J. Atmos. Sci.*, November 1964.

106. McCoy, J. and G. Clark, "Rocketsonde Measurement of Stratospheric Temperature," December 1964.

107. Farone, W. A., "Electromagnetic Scattering from Radially Inhomogeneous Spheres as Applied to the Problem of Clear Atmosphere Radar Echoes," December 1964.

108. Farone, W. A., "The Effect of the Solid Angle of Illumination or Observation on the Color Spectra of 'White Light' Scattered by Cylinders," January 1965.

109. Williamson, L. E., "Seasonal and Regional Characteristics of Acoustic Atmospheres," *J. Geophys. Res.*, January 1965.

110. Armendariz, M., "Ballistic Wind Variability at Green River, Utah," January 1965.

111. Low, R. D. H., "Sound Speed Variability Due to Atmospheric Composition," January 1965.

112. Querfeld, C. W., 'Mie Atmospheric Optics," *J. Opt. Soc. Amer.*, January 1965.

113. Coffman, J., "A Measurement of the Effect of Atmospheric Turbulence on the Coherent Properties of a Sound Wave," January 1965.

114. Rachele, H., and D. Veith, "Surface Wind Sampling for Unguided Rocket Impact Prediction," January 1965.

115. Ballard, H., and M. Izquierdo, "Reduction of Microphone Wind Noise by the Generation of a Proper Turbulent Flow," February 1965.

116. Mireles, R., "An Algorithm for Computing Half Widths of Overlapping Lines on Experimental Spectra," February 1965.

117. Richart, H., "Inaccuracies of the Single-Theodolite Wind Measuring System in Ballistic Application," February 1965.

118. D'Arcy, M., "Theoretical and Practical Study of Aerobee-150 Ballistics," March 1965.

119. McCoy, J., "Improved Method for the Reduction of Rocketsonde Temperature Data," March 1965.

120. Mireles, R., "Uniqueness Theorem in Inverse Electromagnetic Cylindrical Scattering," April 1965.

121. Coffman, J., "The Focusing of Sound Propagating Vertically in a Horizontally Stratified Medium," April 1965.

122. Farone, W. A., and C. Querfeld, "Electromagnetic Scattering from an Infinite Circular Cylinder at Oblique Incidence," April 1965.

123. Rachele, H., "Sound Propagation through a Windy Atmosphere," April 1965.

124. Miers, B., "Upper Stratospheric Circulation over Ascension Island," April 1965.

125. Rider, L., and M. Armendariz, " A Comparison of Pibal and Tower Wind Measurements," April 1965.

126. Hoidale, G. B., "Meteorological Conditions Allowing a Rare Observation of 24 Micron Solar Radiation Near Sea Level," *Meteorol. Magazine*, May 1965.

127. Beyers, N. J., and B. T. Miers, "Diurnal Temperature Change in the Atmosphere Between 30 and 60 km over White Sands Missile Range," *J. Atmos. Sci.*, May 1965.

128. Querfeld, C., and W. A. Farone, "Tables of the Mie Forward Lobe," May 1965.

129. Farone, W. A., Generalization of Rayleigh-Gans Scattering from Radially Inhomogeneous Spheres," *J. Opt. Soc. Amer.*, June 1965.

130. Diamond, M., "Note on Mesospheric Winds Above White Sands Missile Range," *J. Applied Meteorol.*, June 1965.

131. Clark, G. Q., and J. G. McCoy, "Measurement of Stratospheric Temperature," *J. Applied Meteorol.*, June 1965.

132. Hall, T., G. Hoidale, R. Mireles, and C. Querfeld, "Spectral Transmissivity of the Earth's Atmosphere in the 250 to 500 Wave Number Interval," #3, July 1965.

133. McCoy, J., and C. Tate, "The Delta-T Meteorological Rocket Payload," June 1964.

134. Horn, J. D., "Obstacle Influence in a Wind Tunnel," July 1965.

135. McCoy, J., "An AC Probe for the Measurement of Electron Density and Collision Frequency in the Lower Ionosphere," July 1965.

136. Miers, B. T., M. D. Kays, O. W. Thiele and E. M. Newby, "Investigation of Short Term Variations of Several Atmospheric Parameters Above 30 KM," July 1965.

137. Serna, J., "An Acoustic Ray Tracing Method for Digital Computation," September 1965.

138. Webb, W. L., "Morphology of Noctilucent Clouds," *J. Geophys. Res.*, 70, 18, 4463-4475, September 1965.

139. Kays, M., and R. A. Craig, "On the Order of Magnitude of Large-Scale Vertical Motions in the Upper Stratosphere," *J. Geophys. Res.*, 70, 18, 4453-4462, September 1965.

140. Rider, L., "Low-Level Jet at White Sands Missile Range," September 1965.

141. Lamberth, R. L., R. Reynolds, and Morton Wurtele, "The Mountain Lee Wave at White Sands Missile Range," *Bull. Amer. Meteorol. Soc.*, 46, 10, October 1965.

142. Reynolds, R. and R. L. Lamberth, "Ambient Temperature Measurements from Radiosondes Flown on Constant-Level Balloons," October 1965.

143. McCluney, E., "Theoretical Trajectory Performance of the Five-Inch Gun Probe System," October 1965.

144. Pena, R. and M. Diamond, "Atmospheric Sound Propagation near the Earth's Surface," October 1965.

145. Mason, J. B., "A Study of the Feasibility of Using Radar Chaff For Stratospheric Temperature Measurements," November 1965.

146. Diamond, M., and R. P. Lee, "Long-Range Atmospheric Sound Propagation," *J. Geophys. Res.*, 70, 22, November 1965.

147. Lamberth, R. L., "On the Measurement of Dust Devil Parameters," November 1965.

148. Hansen, F. V., and P. S. Hansen, "Formation of an Internal Boundary over Heterogeneous Terrain," November 1965.

149. Webb, W. L., "Mechanics of Stratospheric Seasonal Reversals," November 1965.

150. U. S. Army Electronics R & D Activity, "U. S. Army Participation in the Meteorological Rocket Network," January 1966.

151. Rider, L. J., and M. Armendariz, "Low-Level Jet Winds at Green River, Utah," February 1966.

152. Webb, W. L., "Diurnal Variations in the Stratospheric Circulation," February 1966.

153. Beyers, N. J., B. T. Miers, and R. J. Reed, "Diurnal Tidal Motions near the Stratopause During 48 Hours at WSMR," February 1966.

154. Webb, W. L., "The Stratospheric Tidal Jet," February 1966.

155. Hall, J. T., "Focal Properties of a Plane Grating in a Convergent Beam," February 1966.

156. Duncan, L. D., and Henry Rachele, "Real-Time Meteorological System for Firing of Unguided Rockets," February 1966.

157. Kays, M. D., "A Note on the Comparison of Rocket and Estimated Geostrophic Winds at the 10-mb Level," *J. Appl. Meteor.*, February 1966.

158. Rider, L., and M. Armendariz, " A Comparison of Pibal and Tower Wind Measurements," *J. Appl. Meteor.*, 5, February 1966.

159. Duncan, L. D., "Coordinate Transformations in Trajectory Simulations," February 1966.

160. Williamson, L. E., "Gun-Launched Vertical Probes at White Sands Missile Range," February 1966.

161. Randhawa, J. S., Ozone Measurements with Rocket-Borne Ozonesondes," March 1966.

162. Armendariz, Manuel, and Laurence J. Rider, "Wind Shear for Small Thickness Layers," March 1966.

163. Low, R. D. H., "Continuous Determination of the Average Sound Velocity over an Arbitrary Path," March 1966.

164. Hansen, Frank V., "Richardson Number Tables for the Surface Boundary Layer," March 1966.

165. Cochran, V. C., E. M. D'Arcy, and Florencio Ramirez, "Digital Computer Program for Five-Degree-of-Freedom Trajectory," March 1966.

166. Thiele, O. W., and N. J. Beyers, "Comparison of Rocketsonde and Radiosonde Temperatures and a Verification of Computed Rocketsonde Pressure and Density," April 1966.

167. Thiele, O. W., "Observed Diurnal Oscillations of Pressure and Density in the Upper Stratosphere and Lower Mesosphere," April 1966.

168. Kays, M. D., and R. A. Craig, "On the Order of Magnitude of Large-Scale Vertical Motions in the Upper Stratosphere," *J. Geophy. Res.*, April 1966.

169. Hansen, F. V., "The Richardson Number in the Planetary Boundary Layer," May 1966.

170. Ballard, H. N., "The Measurement of Temperature in the Stratosphere and Mesosphere," June 1966.

171. Hansen, Frank V., "The Ratio of the Exchange Coefficients for Heat and Momentum in a Homogeneous, Thermally Stratified Atmosphere," June 1966.

172. Hansen, Frank V., "Comparison of Nine Profile Models for the Diabatic Boundary Layer," June 1966.

173. Rachele Henry, "A Sound-Ranging Technique for Locating Supersonic Missiles," May 1966.

174. Farone, W. A., and C. W. Querfeld. "Electromagnetic Scattering from Inhomogeneous Infinite Cylinders at Oblique Incidence," *J. Opt. Soc. Amer.* 56, 4, 476-480, April 1966.

175. Mireles, Ramon, "Determination of Parameters in Absorption Spectra by Numerical Minimization Techniques," *J. Opt. Soc. Amer.* 56, 5, 644-647, May 1966.

176. Reynolds, R., and R. L. Lamberth, "Ambient Temperature Measurements from Radiosondes Flown on Constant-Level Balloons," *J. Appl. Meteorol.*, 5, 3, 304-307, June 1966.

177. Hall, James T., "Focal Properties of a Plane Grating in a Convergent Beam," *Appl. Opt.*, 5, 1051, June 1966

178. Rider, Laurence J., "Low-Level Jet at White Sands Missile Range," *J. Appl. Meteorol.*, 5, 3, 283-287, June 1966.

179. McCluney, Eugene, "Projectile Dispersion as Caused by Barrel Displacement in the 5-Inch Gun Probe System," July 1966.

180. Armendariz, Manuel, and Laurence J. Rider, "Wind Shear Calculations for Small Shear Layers," June 1966.

181. Lamberth, Roy L., and Manuel Armendariz, "Upper Wind Correlations in the Central Rocky Mountains," June 1966.

182. Hansen, Frank V., and Virgil D. Lang, "The Wind Regime in the First 62 Meters of the Atmosphere," June 1966.

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Wind regime data in the form of wind roses and frequency of occurrence for nine tower levels by the month and diurnal classification are presented. Results indicate that terrain features in the vicinity of the White Sands Meteorological Research Tower exhibit a modifying effect on the diurnal and seasonal wind regime. It was also found that seasonal variations were in the form of a three season regime system rather than the expected four.

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